Control Measure Evaluation Criteria

Measure

- This can be expressed as an emission limit, VOC content limit, fuel specifications, or other requirement.

Description

- This provides an overall description of the source category and intent of the control measure. It is also useful to know the regulatory history for the source category, including how the potential new requirement differs from existing requirements, or control methods in-use.

Capital Cost

- An estimate of the initial investment by the source to purchase, install, and begin operating the control equipment.

Operating and Maintenance Cost

- Operating costs for a year of normal operation. Components are divided into fixed, variable, and consumable costs.

Annualized Cost

- Converts the capital cost into an equivalent annual cost over the equipment life. This is added to the annual operating and maintenance cost. Credits for recovered materials are subtracted from the total (where applicable).

Control Efficiency

- Percentage reduction from uncontrolled levels. The effects of some control methods may be additive, while others are replacements for existing control techniques.

Cost Effectiveness

- This value is typically the ratio of the expected annualized cost to the expected annual emission benefit. For this study, three values may be of interest: dollars per ton of VOC, dollars per ton of NOx, and dollars per ton of combined VOC plus NOx reduced.

Applicability (source sizes)

- Some measures are only applied to the largest - most cost effective to control - emitters. For example, a major stationary source in the Philadelphia-Wilmington-Trenton area ozone nonattainment is one that emits more than 25 tons per year of VOC or NOx.

Emission reductions (annual, ozone season, episodic) by pollutant

VOC only

NOx only

VOC and NOx

Secondary pollutant benefits - other criteria pollutants, air toxics or greenhouse gases.

Who pays?

- Sources, consumers, governments, etc. Some measures can impose costs on industries and consumers as control costs are passed through.

Administration Issues/Costs

- What burden does the measure place on regulatory agencies? Which agency is responsible for implementing the control measure?

Enforcement

- Is the measure enforceable? Can non-compliers be identified and penalized?

Ease of Compliance Determinations

- This addresses the burden on agencies associated with implementing and enforcing a control measure, and on emission sources associated with recordkeeping and reporting.

Implementation Ease

- This addresses the technical feasibility of implementing a control measure. Has it been implemented in other areas to similar source types?

Timing of Reductions

- Now until 2005
- Post-2005

Emissions Location

- This addresses whether affected sources are inside or outside the five county area, and perhaps the relative distance from the nonattainment area.

Availability

- Is the control technology commercially available?
- High, medium, and low rankings can be assigned to differentiate those that are commercially available, demonstrated for similar, but not the same application, or in pilot plants.

References Used in Evaluation

- Which reports or other data sources were used for this determination? Were control equipment vendors consulted?

Potential Criteria for Evaluating Ozone Control Measures		
1.	Capital Cost	
2.	Operating and Maintenance Cost	
3.	Annualized Direct Costs	
4.	Control Efficiency	% reduction from uncontrolled levels (OTAG uses high 90+%, medium 50-90% and low <50%)
5.	Cost-Effectiveness	cost/ton for each precursor and for both precursors combined, over the lifetime of the control (OTAG proposed - <$1,000/ton, $1,000-5,000/ton, $5-10,000/ton and $10,000+/ton)
6.	Applicability	how many sources, their size
7.	Emission Reductions by Pollutant	estimated reductions-VOC only, NOx only, VOC and NOx combined, secondary pollutant benefit
8.	Who Pays	
9.	Administrative Costs/Issues	
10.	Enforcement (Fed Government & State)	
11.	Ease of Determining Compliance	
12.	Implementation Ease	
13.	Timing of Reductions - Timely	time frame for getting precursor and ozone benefits Now Until 2005 -- Post-2005
14.	Permanence	
15.	Measurable (Quantifiable)	
16.	Publicly Acceptable	
17.	Politically Acceptable	
18.	Consensual	
19.	Available	reliance on commercially available technology - (OTAG-available and transferable, available without proven transferability, not commercially available)
20.	Health Effects	
21.	Economic Impact	

22. Voluntary Measures??

Summary of Potential Control Measures for VOC and NO_x by Source Category

Source Category	Control Measure	Description
VOC Emissions: Surface Coating and Solvent Use		
tighter RACT Industrial Surface Coating (Includes Wood and Metal Products)	(Add-on Controls or VOC Content Limits)	Extending the required RACT standards to smaller sources of VOC emissions (< 50 tpy) not covered by EPA's Control Technique Guidance (CTG) documents; or requiring more stringent limits, improved transfer efficiency, or add-on controls.
over & above national rule Autobody Refinishing	(VOC Content Limits); CA Best Available Retrofit Control Technology	A national rule proposing VOC content limits has been proposed. Can establish more stringent VOC content limits for coatings, require control equipment to improve transfer efficiency, and require add-on controls.
Improvements over CTGs Aerosol Paints	CA Air Resources Board (CARB) Tier 2 Standards; SCAQMD Content Limits	Compliance expected through reformulation.
Surface Cleaning/Degreasing	CARB's Best Available Control Technology; Low-VOC Solvents	Establishes low-VOC targets for solvents; and application methods with high collection and destruction efficiencies.
VOC Emissions: Petroleum Operations, Refueling, Fugitive Emissions		
Gasoline Service Stations: Underground Storage Tanks	Install Pressure Vacuum (PV) Valves on Vent Line	Prevent excessive release of gasoline vapors from storage tank vent pipe.
Improvements to in-place strategies Bulk Terminals	Vapor Recovery System	Reduce VOC emissions during gasoline truck tank loading.
Petroleum Refinery Fugitive Emission Leaks	Inspection and Maintenance Program	Improve compliance with RACT through increased inspection frequency.
VOC Emissions: Miscellaneous Sources		
Rule Effectiveness Improvements	Increase Compliance with Regulations	Options include inspections and other enforcement activities.
beyond RACT Web Offset Lithography	(Carbon Adsorber)	Require controls beyond CTG, such as enclosure installation, and VOC limits for inks.
Controlling some pt categories Graphic Arts	(Low-VOC Inks and Cleaning Solvents)	Extend RACT requirements to small establishments.
Adhesives: Industrial	Reformulation and Product Substitution	Reduce VOC through improved coating types.
New measure Pesticides	Reformulation to Lower VOC Content	Based on California Ozone FIP rule; prohibits use of pesticides above specific VOC limits.

PA will forward 100% MOU commitment in several weeks

Source Category	Control Measure	Description
NO_x Emissions: Fuel Combustion		
Utility Boilers	(Low-NO_x Burner [LNB]) (LNB + Overfire Air) Selective Catalytic Reduction (SCR) Natural Gas Reburn (NGR) Natural Gas Substitution Selective Noncatalytic Reduction (SNCR)	Options include requiring units to meet emission standards beyond RACT requirements based on energy output or heat input. Control techniques vary by boiler type and fuel type. May also ~~be~~ will controlled through OTC Memorandum of Understanding.
Industrial Boilers	(LNB) (LNB + Overfire Air) SCR NGR Natural Gas Substitution SNCR	Control options include establishing emission limits beyond RACT requirements. Control techniques vary by boiler type and fuel type. Large industrial boilers may also be controlled through OTC Memorandum of Understanding.
Adipic Acid Manufacturing Plants	Thermal Reduction	Limits can be set on pounds of
Nitric Acid Manufacturing Plants	Extended Absorption SCR Nonselective Catalytic Reduction (NSCR)	NO_x per ton of acid produced.
Cement Manufacturing	LNB SCR SNCR (Urea-Based)	Require combustion controls and post-combustion controls to achieve reductions on certain processes.
Glass Manufacturing	LNB SCR Oxy-Firing	Require combustion modifications and process changes to achieve reductions beyond those required by RACT.
Gas Turbines: Natural Gas	LNB SCR + Steam Injection	
Gas Turbines: Oil	Water Injection NSCR + Water Injection	
Reciprocating IC Engines: Diesel/Oil	Ignition Timing Retard SCR	
Reciprocating IC Engines: Natural Gas	Air/Fuel (AF) Ratio Adjustment + ITR NSCR	
Process Heaters: Natural Gas or Oil	Ultra-Low-NO_x Burners (ULNB) LNB + SCR LNB + SNCR	
Iron and Steel Mills	LNB + FGR LNB + SNCR LNB + SCR	Control NO_x emissions from reheating, annealing, and galvanizing furnaces.

Source Category	Control Measure	Description
NO_x Emissions: Fuel Combustion (cont'd)		
Industrial, Commercial, and Institutional Combustion	RACT to Small Sources	Extend RACT requirements to smaller sources.
Residential Water Heaters	LNB	New heaters would be required to have low NO_x burners.
Residential Space Heaters	LNB	Programs can provide incentive to replace older heaters.
Medical Waste Incinerators	SNCR	Control NO_x from sterilization techniques.
Municipal Waste Incinerators	SNCR	Set limits beyond EPA's requirements for large facilities.
VOC and NO_x Emissions: On-highway Motor Vehicles		
Light-, Medium-, and Heavy-Duty Diesel Vehicles and Trucks	California Reformulated Diesel Program	CA limits the sulfur content and aromatic hydrocarbon content of motor vehicle diesel fuel.
Light-Duty Gasoline Vehicles and Trucks	More Remote Sensing	The enhanced I/M remote sensing program could be expanded.
Light-Duty Gasoline Vehicles and Trucks	Scrappage Programs	Early retirement of older, higher emitting vehicles.
Heavy-Duty Diesel Trucks	Vehicle Emission Inspections	Some States are considering emission tests of heavy trucks. Primary benefit is to reduce emissions of NO_x and particulates.
Light-, Medium-, and Heavy-Duty Diesel Vehicles and Trucks	Emission-Based Registration Fees	Vehicle operators are charged a registration fee based on annual mileage times the emission rate of one or more pollutants.
All Vehicles	Emission Reduction Credits for Low Emission Vehicle Retrofits for Fleet Vehicles	Issue emission credits to fleet vehicle operators to low emission configurations.
Light-Duty Vehicles and Light-Duty Trucks	Eliminate Excessive Car Dealership Vehicle Starts	Limit car dealers to one fleet engine start-up every two weeks.
All Vehicles	Eliminate Excessive Curb Idling	Limit idling time to 3 minutes.
Urban Buses	Emissions Reduction Credit for Heavy-Duty Buses	Issue emission reduction credit for implementation of low emission buses; require the use of low emission buses (natural gas, methanol, electric trolleys)
All Vehicles	Smoking Vehicle Program	Establishes a call-in line to report vehicles with excessive smoke emissions.

Source Category	Control Measure	Description
VOC and NO_x Emissions: Nonroad Vehicles		
Marine Vessels	Control of Emissions (NO_x) from Ships and Ports	Reduce cruising speeds; engine modifications; clean fuels for shore side equipment; port infrastructure improvements.
Commercial Marine Vessels	Emission fees	Based on California Ozone FIP rule; imposes NO_x emission fee of $10,000 per ton on vessel operators.
Lawn and Garden	Emission Reduction Credits for Leaf Blowers; Electric Lawnmowers	Provide credits for local governments (or other entities) that prohibit leaf blowers, or replace with non-polluting alternatives.
Nonroad	Nonroad Engine Emission Reduction Credit Programs	Provide credits for accelerated retirement and replacement of old engines/vehicles with zero or low-emitting units.
Locomotives	Regional Railroad NO_x Emissions Reduction Measure	Advanced diesel technologies, clean fuels, aftertreatment technologies, electrification.
Aircraft	Control of Emissions from Aircraft and Ground Support Equipment	Single/reduced engine taxiing, reduced airport airside congestion, reduce takeoff power, use only low-emitting aircraft, tow aircraft to runway, increase load factor, GSE electrification.
Locomotive Engines	Potential Federal NO_x Emission Standards	Establishes emission standards to be met by modifying locomotive engines.
	Potential CA NO_x Emission Standards	
≥175 horsepower Compression Ignition (Diesel) Engines: Construction Equipment: Scrapers, Bore/Drill Rigs, Excavators, Cranes, Off-Highway Trucks, Rubber Tired Dozers, and Off-Highway Tractors; Logging Equipment: Fellers/Bunchers	California Phase II Exhaust Standards	Requires modifications to compression ignition engines.
Recreational Vehicles		
2-stroke engine category	Potential CARB Standards	Requires modifications to small, gasoline-powered engines.
4-stroke engine category	Potential CARB Standards	
VOC and NO_x Emissions: Episodic Measures		
Open Burning	Ban on High Ozone Days	Can be implemented when ozone levels are expected to exceed the Federal health standard in order to potentially avoid exceedances.
Commercial Lawn Care	Ban on High Ozone Days	
Recreational Boating	Ban on High Ozone Days	

Source Category	Control Measure	Description
VOC and NO_x Emissions: Episodic Measures (cont'd)		
Motor Vehicles	Voluntary "No-Drive" Measure	Encourage public to reduce driving on high-ozone days.
VOC and NO_x Emissions: Seasonal Measures		
Fuel Combustion	Gas Substitution	Alternative fuel use during ozone season.
Open Burning	Seasonal Ban	Can be implemented during summer months.
Emission Trading Programs		
Stationary Sources	RECLAIM (South Coast, CA)	Includes NO_x and SO_2 emitters of 4 tons per year or more. Emissions Cap and Allocate System.
Stationary Sources	Illinois EPA (Chicago Area)	VOC trading program is an alternative to specified control measures for point sources. May 1-September 30 trading season.

NOTE: Control measures in parentheses are already required in ozone nonattainment areas.

ECOS

Ozone Transport Assessment Group

Mobile Sources Assessment: NOx and VOC Reduction Technologies for Consideration by the Ozone Transport Assessment Group

REVISED FINAL REPORT

Prepared by the OTAG Control Technologies & Options Workgroup, Mobile Sources Committee
April 11, 1996

Ozone
Transport
Assessment
Group

CONTENTS

SECTION 1
OVERVIEW

A wide range of strategies to reduce VOC and NOx emissions from mobile sources were evaluated by the committee. These strategies have been grouped according to the emission source they address: light duty on-highway vehicles (LDVs), heavy-duty on-highway vehicles (HDVs), and non-road engines and vehicles. The tables in Section 2 show the control strategies evaluated for each set of emission sources, along with relevant information concerning their implementation, effectiveness and cost. General descriptions of the controls are included in the appendix to this report. It should be noted that reductions in NOx and VOC emissions resulting from certain control technologies can also result in reductions in particulate matter and air toxics.

Each table shows an estimate of the earliest start date for each program. These start dates assume that OTAG makes its recommendations to EPA sometime in 1997 and that EPA proposes and promulgates its regional strategies by the end of 1998. Also shown are the number of years projected for the program to phase-in. For example, many I/M programs phase in their emission standards. They may also start with a limited number of model years and gradually expand to cover a large part of or the entire in-use vehicle fleet. Likewise, new engine and vehicle standards may apply to 30% of new vehicle sales in the first year of the program, 50% in the second year, etc., until all new vehicles sold are covered by the new requirement.

The columns headed, Years to Achieve Reduction (50%, Full), indicate the number of years after the program start date that would be required for the program's full long-term emission reduction to be achieved. Fuel programs require almost no time to achieve full benefits due to the short life of fuel once produced. Likewise, I/M-like programs also quickly achieve their full eventual benefit. New engine and vehicle programs, however, require the current fleet to wear out and be scrapped (i.e., fleet turnover) before the full benefits of the program accrue. In the second of the two columns, the term full means 90%. Particularly in the case of the new engine and vehicle strategies, turnover of the last pre-controlled vehicles could take 40-50 years, while the vast majority of the benefits accrue after 15-20 years.

The emission reduction percentages shown in the next three columns apply in the year 2007, as this is the year that attainment is required for the severe ozone nonattainment areas with design values above 17 pphm. The emission reductions shown for both LDV and HDV strategies apply to the entire on-road vehicle emission inventory, while those for the non-road engine strategies apply to the entire non-road emission inventory. For example, Basic I/M for LDVs is projected to reduce NOx emissions from LDVs by 0.6% of the NOx emission inventory from both LDVs and HDVs. For those programs showing short times to achieve full reduction, the emission reductions shown for 2007 would not change substantially over time or with a change in start date or phase-in time, as long as the program was not delayed until the 2006-7 time frame. However, for those programs showing longer times necessary to achieve their full reduction potential, the percentage emission reduction is very sensitive to the year being evaluated and will generally increase substantially in each subsequent year.

In this initial phase of information gathering and analysis, these emission reductions were determined relative to the lowest level of control existing in the OTAG region. For example, for LDVs, this was equivalent to the absence of any inspection and maintenance (I/M) program and operation on conventional gasoline. Thus, many of these strategies would not produce any emission benefit in areas already applying these controls. No single emission control baseline is applicable throughout the entire OTAG region. This aspect of the evaluation of the various control strategies is considered an implementation issue that will be addressed at a later date, in particular when the cost effectiveness of further emission controls within ozone nonattainment areas versus the control of transported emissions is addressed. Discussions with the modeling subcommittee also confirmed that the proposed regional ozone modeling would utilize emission inputs which would reflect varying levels of control in different geographical areas. For example, the addition of relatively lenient controls would reduce emissions in areas not having such controls, but would have no effect in areas already at or beyond those controls.

This approach to calculating the emission reductions also means that the emission reductions shown are generally not additive. For example, after implementation of a very stringent I/M program, there are fewer emissions to reduce via reformulated gasoline, and vice versa. The order in which the various programs are implemented can also have a very significant impact on the emission reduction associated with the individual steps. At the present time, however, the appropriate sequence for implementing the various strategies is not available, so the fairest way to present the available information is to use the same baseline for each program. Once an acceptable sequence is available, incremental costs and emission reductions can be calculated and provided.

The estimated costs per ton of the emissions controlled combine the costs of control (to be explained below) and the emission projections just described. It should be noted that costs of control are sensitive to the areal extent of the OTAG region to which controls are applied. The costs per ton shown are those applicable in the long run under steady-state conditions. For fuel programs, capital costs have been amortized over the life of the equipment. For new vehicle and engine programs, emission reductions occurring over the life of the product have been included. Emission reductions were accrued on a year-round basis, in accordance with standard convention. However, this meant that seasonal control programs required special consideration. For example, I/M reduces VOC emissions year-round from vehicles and these year-round reductions were included in the calculation of the cost per ton of VOC controlled for I/M programs. Likewise for new vehicle or engine control programs, the sum of the emission reductions over the life of the engine or vehicle (including both winter and summer operation) was used in estimating cost effectiveness. However, some fuel controls are only applied in the summer (e.g., low-RVP gasoline and the low-RVP requirements in the reformulated gasoline program), since the benefits are most valuable during the summer and refinery and fuel distribution capabilities allow for differing fuel quality between seasons. These seasonal programs could produce the same VOC or NOx emission reduction as a year-round strategy during a typical summer day, but would appear to only provide half the reduction on an annual basis. Thus, the emission reductions for seasonal programs were assumed to occur year-round to produce cost per ton estimates that were comparable to those of year-round programs.

The final column in the table indicates the consumer cost of the controls being evaluated per relevant unit. The relevant unit was either a vehicle or engine or a gallon of fuel. Where a range of costs is shown, almost always the lower limit was provided by EPA or the California Air Resources Board and the upper limit was provided by the industry group being affected. It was not possible to narrow the range of potential costs any further given the resource and time constraints involved.

The control strategies which were evaluated generally fall into four major groups. The first include in-use controls which focus on reducing emissions from sources already produced and in the field. I/M programs for motor vehicles are common examples of such control programs. A range of I/M options was evaluated, as well as enhancements and substitutes to traditional I/M, such as remote sensing and vehicle scrappage programs. In general, in-use programs are characterized by near-term start dates, quick phase-in, and near immediate achievement of full program benefits. Their emission reduction potentials range from low to high (1- 50%). It should be noted that, except for scrappage, the consumer costs shown are only those for inspection. Previous EPA analyses have estimated that the cost of repairing vehicles under enhanced programs would be more than fully compensated by reduced fuel consumption and other operational savings, while the repair costs for basic I/M programs would exceed the resultant savings to some degree. The cost effectiveness figures shown include the net repair costs and savings.

The second group of controls focuses on fuel modifications which do not require special engines or vehicles for their use, such as low-RVP and reformulated gasolines and reformulated diesel fuel. These controls require more lead time than the in-use controls, due to the need to modify refinery equipment. However, once producible, phase-in and ramp-up to full effectiveness are essentially immediate. The effectiveness of fuel-related controls range from low to moderate (1-30%). Costs vary widely (i.e., from <1-30 cents per gallon), as does cost effectiveness.

The third group of controls focuses on the design and production of cleaner engines and vehicles. Prime among these are the National (or 49-State) Low-Emission Vehicle (LEV) program for LDVs and EPA's NOx/PM 10 initiative for HDVs and large non-road engines. These programs require some lead time to develop, design and produce the emission control hardware. However, their most distinguishing feature relative to the in-use and fuel control groups is the time needed to turnover the in-use vehicle fleet to new, cleaner vehicles and engines. These programs typically require 6 - 10 years after the program start date to achieve 50% of their long-term effectiveness and 15-20 years to achieve 90% of long-term effectiveness. Because of this, their effectiveness in 2007 tends to be low to moderate, even though their long-term effectiveness would be much greater. Special note should be made of the benefits of the National LEV program. MOBILE5a only projects significant emission benefits for LEV-like vehicles when enhanced I/M is applied in the area. As indicated in the table, the benefits of the National LEV program are 2-6 times smaller without an I/M program than with enhanced I/M. This synergistic connection between National LEV and I/M is unique among all the control programs listed in the table.

The fourth and last group of controls includes alternative-fuel programs which also require special engines and vehicles for their use (e.g., the Clean Fuel Fleet Program, where natural gas, propane, methanol, etc. are used as fuels). These programs require significant lead time for both the design and production of the engine or vehicle, as well as the production and distribution of the fuel. Due to the absence of current infrastructure for fuel distribution, these programs would generally be limited to centrally fueled fleets or large population areas. Therefore, their overall effectiveness across the OTAG region is generally low.

A number of other control strategies not shown in these tables were also considered. However, insufficient information concerning either their cost, effectiveness, or both, was available to allow their recommendation to the OTAG Policy Group. These control strategies are described in Section 3.

SECTION 2
CONTROL OPTIONS FOR CONSIDERATION

REFERENCES

1. Mobile 5a results, modeled for a hot summer day in July 2007. No I/M program, no anti-tampering program, no RFG, no LEV program. Default values for VMT mix, vehicle age distribution, annual mileage accumulation. 8.7 RVP. Av speed = 19.6 mph. VMT in cold-start = 20.6%, in hot-start = 27.3% and in hot-stabilized = 52.1. 0% ether blends, 15% alcohol blends.

2. "The Cost-Effectiveness of Further Regulating Mobile Source Emissions"; Sierra Research, Inc., and Charles River Associates; February 28, 1994.

3. U.S. Environmental Protection Agency - Office of Mobile Sources data.

4. BP Oil Company data.

5. U.S. Environmental Protection Agency - Complex Model results.

6. "Draft Discussion Paper for the Low-Emission Vehicle and Zero-Emission Vehicle Workshop on March 25, 1994"; California Environmental Protection Agency, Air Resources Board.

7. "Regulatory Impact Analysis, Clean Fuel Fleet Program"; U.S. Environmental Protection Agency; June 1994.

8. Benefits from Coordinated Research Council Fuel Studies - VE-1 & VE-10; costs from Ethyl Corporation.

9. "Regulatory Support Document, Emission Standards for Heavy-Duty Clean-Fuel Fleets'; U.S. Environmental Protection Agency; June 1994.

10. Based on data from the reg-neg on handheld and nonhandheld 0 - 25 hp gasoline-powered engines.

SECTION 3
OTHER CONTROL OPTIONS

As referenced at the end of the overview to this report, the committee considered a number of other mobile source control options during the development of the matrix. However, because the effectiveness or cost data was too "soft", containing an unacceptable level of uncertainty, these options were not included in the committee's recommendation to OTAG. Instead, for purposes of information and possible consideration for incorporation in a trading program or future inclusion in regional or local strategies for ozone reduction, they are listed below.

Light-duty, on-highway:

Emission control upgrade

Light-duty gasoline-powered vehicles which exhibit high emissions after remedial repairs, but which are not suitable for scrappage, would be candidates for installing upgraded emission control components. Types of emission control upgrades include: 1) installing a three-way converter with auxiliary controls on a two-way converter equipped vehicle; 2) replacing the existing three-way converter on an older, higher mileage vehicle with a current, advanced design three-way converter; 3) adding a light-off or "pre-converter"; 4) installing a hydrocarbon absorber; and 5) upgrading the evaporative emission canister.

Since the concept of emission control upgrades is in the early stages of evaluation, it is difficult to quantify the potential emission reduction benefits or the cost effectiveness. The Manufacturers of Emission Controls Association did conduct a preliminary analysis entitled "Emission Control System Upgrades for Gasoline-Powered Light-Duty Vehicles" (1995) which suggested that the emission reductions potential merited further evaluation of the upgrade concept.

Advanced Technology Vehicle (ATV)

Examples of ATVs include Ultra Low-Emission Vehicles (ULEVs), Inherently Low-Emission Vehicles (ILEVs), and Zero Emission Vehicles (ZEVs). Assuming that the National LEV is implemented, introduction of ATVs would likely occur as part of a program that shares responsibility among states, EPA, DOE, fuel providers, after-market converters, fleet operators and motor vehicle manufacturers and that is influenced by the Energy Policy Act or any other state or federal programs. The emission reduction impacts will depend largely on the development of an appropriate infrastructure and on numbers and types of ATVs sold.

Fuel additives

Fuel additives are blended into gasoline at either the refinery or at the bulk terminal to boost octane, to reduce fuel injector and intake valve deposits, or to otherwise enhance the quality and performance of the fuel. Secondarily, these additives may also affect exhaust emission levels, with varying impacts on NOx, VOC, CO and toxic emissions. Research is continuing to determine the direct and indirect effects of their use.

This control could apply to heavy-duty, on-highway mobile sources as well.

CAFE Standards

Corporate average fuel economy (CAFE) standards require the average fuel economy of new vehicle sales to meet or exceed the specified level. As such, CAFE standards reduce the amount of fuel consumed per mile driven as the fleet turns over. By reducing the amount of fuel consumed per mile, CAFE standards reduce the incremental cost of driving, which tends to encourage more driving. Thus, CAFE standards may not reduce fleet-wide fuel consumption to the degree implied by the simple change in fuel economy level.

Moreover, CAFE standards have no direct effect on NOx, HC (or VOC) and CO emissions. The standards for these pollutants apply on a per mile basis, e.g., 0.6 g/mi NOx for Tier 1 light-duty vehicles. If fuel economy increases, less fuel is burned per mile and carbon dioxide emissions will decrease, but the form of the current HC, CO, and NOx emissions standards allows the same amount of HC, CO and NOx to be emitted on a per mile basis. Reductions in HC, CO and NOx emissions would require more stringent standards for these pollutants, which is already being addressed through the National LEV program. Insofar as increased fuel economy encourages additional driving, fleet-wide HC, CO and NOx emissions may increase due to increased CAFE standards. Thus, raised CAFE standards are not recommended as an NOx, HC (VOC) or CO emission control strategy.

Reduced VMT

Reducing vehicle miles traveled (VMT) directly reduces VOC and NOx emissions on a one-to-one basis, i.e., a 10% reduction in VMT leads to a 10% reduction in emissions. However, the emission reduction benefits and costs are highly variable for the individual control measures in this category. In addition, the measures may not be implementable in non-urban areas for various technical, economic and political reasons. Therefore, this control category is not recommended for OTAG-wide consideration. However, the committee recommends that federal, state and local air officials consider these measures for adoption in SIPs for nonattainment areas.

This control could apply to heavy-duty, on-highway mobile sources as well.

Reduced Speed Limit

According to a recent EPA memo, issued in response to the elimination of the national highway speed limit, increasing rural highway speeds to 65 mph would increase NOX emissions by at least 5 percent. Modeling results indicate that NOX emissions may increase as much as 9 percent along portions of the I-95 corridor in the OTR. Carbon monoxide emissions are also predicted to increase because of reduced fuel economy at higher highway speed. Conversely, reducing rural speed limits should reduce NOX and CO emissions. However, this data has not been critically reviewed and is not accepted for inclusion in this report.

This control could apply to heavy-duty, on-highway mobile sources as well.

Heavy-duty, on-highway:

Engine Retrofit/Rebuild

The concept of diesel-powered HDE fuel conversion, emission control retrofit, and engine rebuild upgrade is not new: a great deal of experience has been gained with alternative fuel conversions; control retrofit and engine rebuild upgrade kits have been EPA certified as part of the Agency's urban bus engine retrofit/rebuild program; and a significant number of mining and industrial vehicles have been retrofitted with emission controls over the years. The NOX reduction potential of fuel conversions has been demonstrated. Until recently, however, the focus of HDE emission control retrofits and rebuild upgrade kits has been to reduce particulates, CO and/or odor. Nevertheless, development work is under way to produce integrated control retrofit/rebuild kits which reduce NOX emissions. For example, a system certified under EPA's urban bus retrofit/rebuild program uses a combined strategy of engine timing retard, internal ceramic engine coatings, and an oxidation catalyst to achieve a 40% reduction in NOX emissions, as well as a 25% reduction in particulates. It is difficult to quantify the benefits of a fuel conversion/retrofit/rebuild strategy because it is dependent on such factors as the control strategy selected and the numbers and types of engines involved.

This control could apply to non-road diesel sources as well.

APPENDIX
DESCRIPTIONS OF MOBILE SOURCE CONTROL TECHNOLOGIES

Selected chapters from:

Controlling Nitrogen Oxides Under the Clean Air Act: *A Menu of Options*

State and Territorial Air Pollution Program Administrators
and Association of Local Air Pollution Control Officials, July 1994

For the complete Appendix, see the Preliminary Report, dated January 19, 1996.

Or, see the following chapters in STAPPA/ALAPCO's Controlling Nitrogen Oxides Under the Clean Air Act: *A Menu of Options* :

"Motor Vehicle Inspection and Maintenance", pp. 135-141;
"Reformulated Gasoline and Diesel Fuels", pp. 142-148;
"California Low-Emission Vehicles", pp. 149-156;
"Clean-Fuel Fleets", pp. 157-167;
"Nonroad Vehicles and Engines", pp. 168-175 and
"Accelerated Vehicle Retirement", pp. 184-188.

OTAG Mobile Sources - Phase II Control Options

Non-road: Control option	Earliest start date	Years to phase in	Years to Achieve Reduction 50%	Full	Total Non-road % Reduction (Yr 2007) [6] NOx	VOC	CO	Estimated Cost ($ per ton) [7] NOx	VOC	NOx+VOC	Estimated cost to consumer ($ per unit)	Ref.
HEAVY DUTY												
Clean fuels												
Reform diesel												
45 -> 53 cetane	2000	0	0	0	3.4 [14]	0	0	3600 - 10,600	na	3600 - 10,600	1.8 - 5.1 cpg	8
45 -> 50 cetane	2000	0	0	0	1.7	unk	0	2200 - 5500	na	2200 - 5500	0.8 - 1.9 cpg	4
50 -> 55 cetane	2000	0	0	0	1.1	unk	0	8000 - 23,000	na	8000 - 23,000	1.8 - 5.3 cpg	4
Low NOx fuels [12]	1998	0	0	0	11 [*,14]	0	unk	39,600 [*]	na	39,600 [*]	1.40/gal	3
NOx/PM initiative [15]												
6.9 -> 5.2 g/hp-hr	2004	1	7	20	3.4	0	na	119	na	119	133/eng	3
6.9 -> 4.0 g/hp-hr	2002	3	8	22	7.9	0	na	177	na	177	226/eng	3
OTHER												
Sm gasoline engines												
Phase II (30/25)					-0.3	9.6	na					
Handheld	2002	4	3	7				na	na	5300	var	10
Non-handheld	2002	0	3	7				na	na	53	var	10
CARB certified					-0.3	17.1	na					
Handheld	1999	0	1	3				na	na	> 5300	unk	10
Non-handheld	1999	0	3	7				na	na	> 8000	unk	10
CARB (in-use + evap)					-0.3	22.9	na					
Handheld	1999	0	1	3				na	na	> 5300	unk	10
Non-handheld	1999	0	3	7				na	na	> 8000	unk	10
Recreational marine [16]												
New av std	1998	9	13	40	0.4	10.8	na	na	700	700	var	3
Locomotives [17]												
New av std	2000	5	3	30	7.7 [18]	negl	unk	840 [18]	na	840 [18]	$280K - 440K	3

Notes:

[*] - Estimate based on very limited information and subject to a high level of uncertainty.
[6] - The base for these reductions is all non-road mobile sources in a typical attainment area, without any Phase I control measures.
[7] - Average cost (not marginal).
[12] - Applicability may be limited because of low availability.
[14] - Fuel must be used in marine, locomotive, and all other diesel engines to gain full benefits.
[15] - EPA is seeking an agreement or rule to limit NOx and PM from non-road engines, excluding recreation, lawn/garden, marine, locomotive, aircraft.
[16] - Proposed rule applies average emission standard, offering manufacturers flexibility in producing cleaner engines.
[17] - Proposed rule seeks to reduce NOx and PM. Also, encourages retrofitting for accelerated reduction benefits.
[18] - Calculated benefits and costs include rebuil^^

Heavy-duty, on-hwy: Control option	Earliest start date	Years to phase in	Years to Achieve Reduction 50%	Full	Total (LD+HD) On-Highway % Reduction (Yr 2007) [7] NOx	VOC	CO	Estimated Cost ($ per ton) [8] NOx	VOC	NOx+VOC	Estimated cost to consumer ($ per unit)	F
In use (gasoline-powered)												
I/M	2000	4	2	4	0.8	1.7	0.7	2500 [*]	1000 [*]	700 [*]	10/veh/yr	1
Remote sensing	2000	2	2	4	0.2 [*]	0.4 [*]	0.2 [*]	2500 [*]	1000 [*]	700 [*]	51/veh/yr [10]	1
OBD	2002	0	10	20	0.3	0.2	0.1	1000 [*]	1000 [*]	500 [*]	5/veh/yr	1
Clean fuels												
Reform diesel												
45 -> 53 cetane	2000	0	0	0	1.2	0	negl	6900 - 19,500	na	6900 - 19,500	1.8 - 5.1 cpg	8
45 -> 50 cetane	2000	0	0	0	0.7	1.8	1.0	3500 - 8300	1100 - 2700	840 - 2000	0.8 - 1.9 cpg	4
50 -> 55 cetane	2000	0	0	0	0.4	1.0	0.6	13,500 - 40,000	4700 - 13,500	3500 - 10,000	1.8 - 5.3 cpg	4
Biodiesel blend (B20)	2000	0	0	0	0.02	unk	unk	6,000,000	na	6,000,000	39 cpg	4
Low NOx fuels [12]	1998	0	0	0	2.5 [*]	0	unk	170,000 [*]	na	170,000 [*]	1.40/gal	3
Clean fuel fleets	1998	3	3	10	2.2	0.1	= Tier 1	2900	11,400	2300	515/veh	1,
NOx initiative [13]												
3 g/hp-hr std	2004	0	9	30	2.8	negl	na	400 - 1000 [*]	na	400 - 1000 [*]	200 - 700/eng	1,
2 g/hp-hr std	2004	0	9	30	5.6	negl	na	200 - 500 [*]	na	200 - 500 [*]	200 - 700/eng	1,

Notes:

[*] - Estimate based on very limited information and subject to a high level of uncertainty.

[7] - The base for these reductions is all highway vehicles in a typical attainment area, without any Phase I in-use, clean fuels or other control measures.

[8] - Average cost (not marginal).

[10] - Field costs for testing 20% of the fleet, plus cost of high enhanced I/M support.

[12] - Applicability may be limited because of low availability.

[13] - Proposed rule to reduce allowed emission rate is due. Based on agreement between HD engine manufacturers, EPA and State of California

OTAG Mobile Sources - Phase II Control Options

04/11/96

Light-duty, on-hwy: Control option	Earliest start date	Years to phase in	Years to Achieve Reduction 50%	Full	Total (LD+HD) On-Highway % Reduction (Yr 2007) [6] NOx	VOC	CO	Estimated Cost ($ per ton) [7] NOx	VOC	NOx+VOC	Estimated cost to consumer ($ per unit)	Re[illegible]
Non-FTP rule [1]	1998	3	7	15 - 25	2.4 - 5.8	1.5 - 2.7	yes	850 - 30,000	2100 - 55,000	600 - 19,000	10 - 145/veh	3
In use												
I/M												
Basic	2000	2	1	4	0.6	7.0	10.0	40,000 - 95,000	3800 - 9000	3500 - 8200	8 - 18/veh/yr [8]	1
Basic NOx [2]	2000	4	2	4	14.0	15.0	26.0	1100	1000	550	7/veh/yr	1
Low enhanced	2000	4	2	4	1.0	9.0	14.0	32,000 - 75,000	3000 - 7000	2800 - 6500	8-18/veh/yr [8]	1
High enhanced	2000	4	2	4	17.0	41.0	38.0	2200	900 - 3200	650 - 2400	10 - 22/veh/yr	1,2
Maximum [3]	2000	3 - 4	1	3 - 4	21.0	50.0	48.0	3300	1400	1000	19/veh/yr	1
Remote sensing	2000	2	2	4	4 [*]	10 [*]	10 [*]	2500 [*]	1000 [*]	700 [*]	51/veh/yr [9]	1
Scrappage	1999	1	2 [*]	4 [*]	<1 [*]	<1 [*]	2 [*]	var	26,000 [10]	18,000 [10]	500 -2000/veh	1,2
Clean fuels												
Low RVP												
9.0 -> 7.1 psi	2002	0	0	0	0 - 0.4	16.9	3.0	16,000 - ?	320 - 1400	320 - 1400	0.36 - 1.6 cpg [11]	1,3,
9.0 -> 6.7 psi	2002	0	0	0	0 - 0.5	21.0	3.0	15,000 - ?	300 - 1600	300 - 1600	0.42 - 2.2 cpg [11]	1,3,
9.0 -> 7.8 psi	2000	0	0	0	0 - 0.3	10.0	3.0	12,000 - ?	300 - 760	300 - 760	0.20 - 0.5 cpg [11]	1,3,
7.8 -> 7.0 psi [4]	2002	0	0	0	0 - 0.2	8.0	0	15,000 - ?	300 - 2300	300 - 2300	0.16 - 1.2 cpg [11]	1,3,
Low sulfur (150 ppm)	2004	0	0	0	4.4	2.2 - 5.3	3.3 - 8.0	4100 - 12,000	2900 - 21,000	1700 - 7700	1.0 - 3.0 cpg [11]	3,4,
Fed RFG - Phase I	2004	0	0	0	1.1 - 2.2	13.4	17.1	43,000 - 120,000	5900 - 8200	5200 - 7700	5.2 - 7.3 cpg [12]	3,4,
- Phase II	2004	0	0	0	4.8	25.2	17.1	25,000 - 45,000	4000 - 7100	3500 - 6200	6.7-11.9 cpg [12]	3,4,
CA Phase II	2004	0	0	0	7.8 - 10.0	26.9	17.1	30,000 - 60,000	9300 - 15,000	7100 - 12,000	16.5 - 26 cpg [13]	3,4,
Clean fueled fleets	1998	3	3	10	0.70	0.42	0.74	56,000 - 260,000	36,000 - 165,000	22,000 - 100,000	180 - 844/veh	1,2,
National LEV												
w/o I/M	2001	0 - 4	6 - 7	14 - 15	3.0 - 3.7	2.5 - 3.0	4.0 - 6.0	11,000 - 56,000	11,900 - 60,000	5800 - 29,000	114 - 576/veh	1,2,
w/LEV-only I/M [5]	2001	0	6	14	14	16	19	3100 - 8900	2000 - 5800	1200 - 3400	+ 7/veh/yr	1,2,
w/OBD check only	2001	0	10	20	5 [*]	9 [*]	10 [*]	unk	unk	unk	unk	1

Notes:

[*] - Estimate based on very limited information and subject to a high level of uncertainty.
[1] - Expected control through rulemaking process as part of Phase I; NPRM published 1995.
[2] - "Basic NOx" includes IM240 testing on vehicles 6 to 16 years old. NOx cutpoints are EPA high-enhanced standard. HC & CO are lenient. No evap.
[3] - "Maximum" is annual IM240 with cutpoints at 75% of EPA high-enhanced standard. Evap & purge also.
[4] - Incremental effectiveness and cost.
[5] - "LEV-only I/M" includes additional requirements as specified in EPA guidance. Also includes evap benefits.
[6] - The base for these reductions is all highway vehicles in a typical attainment area, without any Phase I in-use, clean fuels or other control measures.
[7] - Average cost (not marginal).
[8] - $8 for annual test-only program and $18 for annual test-and-repair program.
[9] - Field costs for testing 20% of the fleet, plus cost of high enhanced I/M support.
[10] - Estimate based on $700/veh California program.
[11] - Annualized costs for summertime program.
[12] - Lower limit may be at least 0.4 cents lower, based on ARCO Chemical's estimate of the future cost of oxygenates, and refinery costs if application is less than OTAG-wide..
[13] - Lower limit may be significantly lower based [illegible] market pric[illegible] [illegible] California.

ASSESSMENT OF CONTROL TECHNOLOGIES FOR REDUCING NITROGEN OXIDE EMISSIONS FROM NON-UTILITY POINT SOURCES AND MAJOR AREA SOURCES

I. Introduction

This document provides a brief overview of NOx control technologies for non-utility fossil-fuel fired boilers, other stationary sources of NOx, and major area sources. The information presented is drawn from presentations made to the OTAG Control Technologies Workgroup, from documents provided by affected industries, and from knowledgeable sources such as USEPA and STAPPA/ALAPCO.

As is stated in the companion document on NOx emission reduction technologies for electric utilities, the objective of this report is to provide a brief review of currently available technology options for the sources indicated. There is no single preferred technology, nor does this report prioritize or rank the technologies discussed according to effectiveness or preference. Some technologies may have multiple applications, while others may be limited in their utility. This workgroup has attempted insofar as possible to avoid making choices which would lead to a limitation of policy options.

II. Universe of Sources

Prior to a discussion of available control technologies, it would be helpful to describe the universe of sources being considered. These range from large non-utility boilers used by major industries to chemical manufacturing and metals processing, and from pulp and paper mills to waste disposal through incineration. Of these sources, fossil fuel combustion accounts for approximately 75% of the total NOx emissions. A list of the general source categories is shown on Page 6. This report covers the first nine categories, accounting for nearly 87% of all non-utility point source and area source NOx emissions. The remaining categories were not considered due to their relatively small contributions, the nature of the particular sources, and the limited amount of time available to the workgroup.

Pages 7-8 provide a more detailed assessment of the character of both the universe of sources and the nature of the NOx emissions. As can be seen, most of these sources make relatively small contributions. It must also be remembered that, unlike utilities, this is a disparate group of sources, some of which are currently regulated, some of which will be regulated in the near future, and some of which are not regulated at all. Thus the potential for reductions varies not only with their relative contribution but with the potential for control as well.

III. Control Technologies

This section presents a brief description of the control technologies available for each category of sources. Information for this discussion, as noted above, was provided by industry representatives, USEPA, STAPPA/ALAPCO, and others.

A. Non-Utility Boilers

The technologies for controlling emissions from non-utility boilers is largely identical to that for utility boilers. The reader is referred to the discussion of utility boiler controls in "Electric Utility Nitrogen Oxides Reduction Technology Options" also prepared by this workgroup.

B. Reciprocating Internal Combustion Engines

Several strategies are available for controlling NOx emissions from reciprocating engines. Air/fuel ratio adjustment, low emission combustion, and pre-stratified charge all function by modifying the combustion zone air/fuel ratio, in turn influencing oxygen availability and peak flame temperature. Ignition timing adjustment lowers the peak flame temperature by delaying the onset of combustion. SCR and SNCR alter the chemical properties of NOx after its formation. Finally, some companies have developed "low-NOx fuels," which reduce NOx emissions by adjusting inputs. Further information on each of these technologies may be found in "Controlling Nitrogen Oxides Under the Clean Air Act: A Menu of Options," prepared by STAPPA/ALAPCO.

C. Gas Turbines

Controlling NOx emissions from gas turbines may be accomplished through water or steam injection into the combustion chamber, lowering peak temperatures and reducing the formation of thermal NOx; lean pre-mixed combustion, which reduces flame temperatures by injecting excess air; and SCR. Further information on each of these technologies may be found in "Alternative Control Techniques Document--NOx Emissions from Stationary Gas Turbines," published by USEPA.

D. Residential Fuel Combustion

During ozone season, residential fuel combustion is used to produce hot water and to operate air conditioning units. Typical fuels are electricity and natural gas.

Reducing electrical demand, and therefore utility emissions, may be accomplished through replacement of existing units with units of higher efficiency, with improved insulation and other external improvements, and with partial or full solar units, when feasible. Reducing NOx emissions from natural gas units is generally accomplished through replacement with units of higher efficiency or low-NOx burners, along with solar-assisted water heating.

The South Coast Air Quality Management District has developed regulations for controlling NOx emissions from residential fuel combustion.

E. Cement Manufacturing

Cement kilns are similar in concept to boilers in that they use a fossil fuel to create very high temperatures which chemically alter the raw materials. Almost all of the NOx emissions from cement kilns are the result of fuel combustion.

Controlling NOx emissions from cements kilns is accomplished through combustion controls, such as flame control, changes in fuel input parameters, preheating the raw material inputs, and the use of additives. According to USEPA, SNCR may be applicable to some types of kilns as well, although some increases in ammonia emissions may occur as a result. SCR may also be used. Further information on these technologies may be found in "Controlling Nitrogen Oxides" from STAPPA/ALAPCO, and in the ACT document "Control of NOx Emissions from Cement Manufacturing" from USEPA.

F. Ferrous Metals Processing

Although the production of iron and steel finished products is a fairly complex process, the vast majority of NOx emissions come from the use of fossil fuels to heat the furnaces in which the ores are reduced and separated. Emission reduction technologies include low-NOx burners, flue gas recirculation, SCR and SNCR. Typically, low-NOx burners are used in combination with flue gas recirculation in reheating furnaces, and with SCR or SNCR in annealing furnaces. The USEPA has developed an ACT document entitled "NOx Emissions from Iron and Steel Mills." Further information on control technologies may also be obtained from STAPPA's NOx control handbook.

G. Wood, Pulp, and Paper Manufacturing

Wood, pulp, and paper manufacturing involves three basic processes. Industrial boilers are used to produce steam and power, and are fueled by fossil fuels and/or wood waste products. Recovery boilers evaporate water from the effluents and reduce the remaining chemicals and waste products to a form appropriate for recycling. Lime kilns are used to recover the calcium oxide used in treating the effluents in the recovery boilers.

NOx emissions reductions from the industrial boilers may be reduced using the same techniques described in the section on utility boilers. Emissions from lime kilns may be reduced in the same manner as those described for cement kilns.

Emissions from recovery boilers are generally not thermally produced, and are therefore not sensitive to reductions in flame temperature. Changes in the process, including low excess air and air staging, may reduce NOx emissions somewhat. SNCR may also be used as a post-process reduction technique.

H. Agricultural Chemicals

The production of agricultural chemicals, chiefly ammonia and nitric acids used for fertilizer, is largely uncontrolled with respect to NOx emissions. Ammonia production utilizes a high-temperature boiler to produce steam, from which the hydrogen is stripped. It is later mixed with nitrogen, purified, and dried, producing ammonia. Controlling NOx emissions from the boiler may be accomplished as described in previous sections.

Nitric acid is produced by a three-step process: 1) combining oxygen and ammonia to produce nitric oxide; 2) mixing nitric oxide with air to produce nitrogen dioxide; and 3) absorption of the nitrogen dioxide in water to produce "weak" nitric acid. NOx emissions are produced at the end of the process, as waste gases are vented. Generally, these gases are run through an absorber tower. Reducing emissions can be accomplished by extending the absorption time, either by increasing the height of the tower or by adding a second tower in series with the first. SCR and non-selective catalytic reduction (NSCR) may also be used, although NSCR requires an additional fuel and catalyst. The USEPA has published an ACT document for nitric acid production. Further information on reducing NOx emissions from ammonia and nitric acid production may be obtained from the STAPPA handbook on NOx control.

I. Oil and Gas Production

NOx emissions from oil and gas production come from refineries, which use process heaters, boilers, catalytic cracking units, and tail gas incinerators. NOx control techniques for process heaters and boilers have been described above. NOx emissions from the catalytic cracking units may be reduced through process changes, such as minimizing excess air in the flue gas or changing the input mix. NOx emissions from tail gas incinerators may be reduced with SNCR or low-NOx burners. Further information may be obtained from the STAPPA handbook on NOx control.

J. Waste Incineration

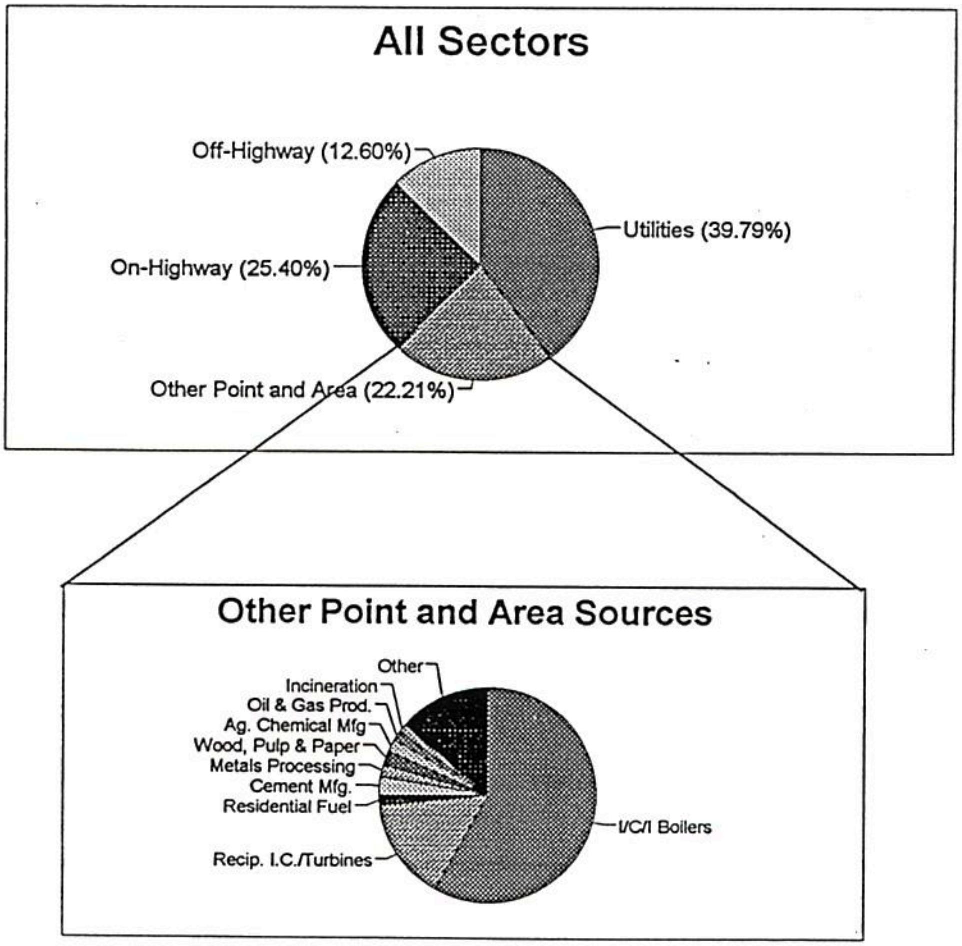
Waste incineration includes municipal, medical, hazardous, and sewage sludge incineration. NOx emission controls include process changes, such as low excess air, staged combustion, flue gas recirculation, and gas reburning; as well as post-process controls (SCR and SNCR).

Municipal and medical waste incinerators are the subject of recent USEPA rulemaking, and emissions from these sources will be reduced in the near future. Further information may be obtained from the USEPA.

Attachment

NOx Sector Contribution - preliminary
1990 OTAG Inventory

ALL SECTORS		
Source Category	NOx (tpd)	% of Total
Utilities	20387.81	39.79%
Other Point and Area	11377.96	22.21%
On-Highway	13013.24	25.40%
Off-Highway	6455.89	12.60%
TOTAL =	51234.90	100.00%



Prioritized Contribution of NOx Source Categories, from EPA's Tier 3 Summary

Dated December 1995

	General Source Category	Specific Source Category	TPD	Cum. %
1	FUEL COMB.	I/C/I Boilers	6601.30	58.02%
2	FUEL COMB.	Recip. I.C. Engines/Gas Turbines	1738.33	73.30%
3	FUEL COMB.	Fuel Comb. - Residential	192.39	74.99%
4	OTHER INDUSTRIAL PROCESSES	Mineral Products - cement mfg.	294.47	77.58%
5	METALS PROCESSING	Ferrous	225.50	79.56%
6	OTHER INDUSTRIAL PROCESSES	Wood, Pulp & Paper, & Publishing Products	235.35	81.63%
7	CHEMICAL & ALLIED PRODUCT MFG	Agricultural Chemical Mfg	205.51	83.43%
8	PETROLEUM & RELATED INDUSTRIES	Oil & Gas Production	164.52	84.88%
9	WASTE DISPOSAL & RECYCLING	Incineration	148.27	86.18%
10	OTHER INDUSTRIAL PROCESSES	Agriculture, Food, & Kindred Products	143.43	87.44%
11	SOLVENT UTILIZATION	Surface Coating	122.21	88.52%
12	OTHER INDUSTRIAL PROCESSES	Mineral Products - glass mfg.	118.34	89.56%
13	MISCELLANEOUS	Other Combustion	115.68	90.57%
14	PETROLEUM & RELATED INDUSTRIES	Petroleum Refineries & Related Industries	112.89	91.56%
15	WASTE DISPOSAL & RECYCLING	Open Burning	67.64	92.16%
16	CHEMICAL & ALLIED PRODUCT MFG	Organic Chemical Mfg	63.20	92.71%
17	STORAGE & TRANSPORT	Organic Chemical Storage and Transport	55.29	93.20%
18	WASTE DISPOSAL & RECYCLING	POTW	33.71	93.50%
19	CHEMICAL & ALLIED PRODUCT MFG	Inorganic Chemical Mfg	33.58	93.79%
20	STORAGE & TRANSPORT	Inorganic Chemical Storage	30.90	94.06%
21	METALS PROCESSING	Non-Ferrous Metals Processing	26.63	94.30%
22	WASTE DISPOSAL & RECYCLING	Other	23.26	94.50%
23	CHEMICAL & ALLIED PRODUCT MFG	Polymer & Resin Mfg	22.06	94.70%
24	SOLVENT UTILIZATION	Graphic Arts	20.71	94.88%
25	OTHER INDUSTRIAL PROCESSES	Miscellaneous Industrial Processes	18.71	95.04%
26	PETROLEUM & RELATED INDUSTRIES	Asphalt Manufacturing	18.52	95.20%
27	METALS PROCESSING	Metals Processing NEC	17.59	95.36%
28	WASTE DISPOSAL & RECYCLING	Landfills	17.38	95.51%
29	STORAGE & TRANSPORT	Pet. & Pet. Prod. Storage and Transport	15.41	95.65%
30	OTHER INDUSTRIAL PROCESSES	Rubber & Miscellaneous Plastic Products	15.33	95.78%
31	OTHER INDUSTRIAL PROCESSES	Machinery Products	11.66	95.88%
32	STORAGE & TRANSPORT	Bulk Terminals & Plants	11.01	95.98%
33	OTHER INDUSTRIAL PROCESSES	Textiles, Leather, & Apparel Products	10.05	96.07%
34	CHEMICAL & ALLIED PRODUCT MFG	Paint, Varnish, Lacquer, Enamel Mfg	6.13	96.12%
35	CHEMICAL & ALLIED PRODUCT MFG	Pharmaceutical Mfg	1.27	96.13%
36	OTHER INDUSTRIAL PROCESSES	Transportation Equipment	0.96	96.14%
37	SOLVENT UTILIZATION	Degreasing	0.84	96.15%
38	SOLVENT UTILIZATION	Other Industrial	0.27	96.15%
39	OTHER INDUSTRIAL PROCESSES	Mineral Products - misc.	222.26	98.11%
40	OTHER INDUSTRIAL PROCESSES	Electronic Equipment	0.12	98.11%
41	CHEMICAL & ALLIED PRODUCT MFG	Other Chemical Mfg	215.29	100.00%
42	SOLVENT UTILIZATION	Dry Cleaning	0.02	100.00%
43	STORAGE & TRANSPORT	Service Stations: Stage I and II	0.00	100.00%
44	STORAGE & TRANSPORT	Bulk Materials Storage	0.00	100.00%
45	WASTE DISPOSAL & RECYCLING	TSDF	0.00	100.00%
		TOTAL	11377.96	

* These categories represent numerous sub-categories too small and diverse to warrant individual attention, and are therefore taken out of contention for consideration.

Background - EPA Preliminary Tier 3 Summary of NOx Emissions in Tons/Summer Day

Dated December 1995

TIER1	TIER2	TIER	TIER1NAME	TIER2NAME	TIER3NAME	POINT	AREA	TOTAL	ref
01	01	01	FUEL COMB. ELEC. UTIL.	Coal	bituminous	14043.30	0.00	14043.30	1
01	01	02	FUEL COMB. ELEC. UTIL.	Coal	subbituminous	2085.46	0.00	2085.46	1
01	01	03	FUEL COMB. ELEC. UTIL.	Coal	anthracite & lignite	858.83	0.00	858.83	1
01	01	99	FUEL COMB. ELEC. UTIL.	Coal			5.16	5.16	1
01	02	01	FUEL COMB. ELEC. UTIL.	Oil	residual	1085.37	0.00	1085.37	1
01	02	02	FUEL COMB. ELEC. UTIL.	Oil	distillate	277.46	0.42	277.88	1
01	03	01	FUEL COMB. ELEC. UTIL.	Gas	natural	1162.13	0.39	1162.52	1
01	03	02	FUEL COMB. ELEC. UTIL.	Gas	process	30.78	0.00	30.78	1
01	04	99	FUEL COMB. ELEC. UTIL.	Other		56.97	0.00	56.97	1
01	05	99	FUEL COMB. ELEC. UTIL.	Internal Combustion		769.23	12.31	781.54	1
02	01	01	FUEL COMB. INDUSTRIAL	Coal	bituminous	1086.48	0.00	1086.48	2
02	01	02	FUEL COMB. INDUSTRIAL	Coal	subbituminous	12.38	0.00	12.38	2
02	01	03	FUEL COMB. INDUSTRIAL	Coal	anthracite & lignite	60.18	0.84	61.02	2
02	01	99	FUEL COMB. INDUSTRIAL	Coal			421.76	421.76	2
02	02	01	FUEL COMB. INDUSTRIAL	Oil	residual	298.90	156.01	454.91	2
02	02	02	FUEL COMB. INDUSTRIAL	Oil	distillate	59.18	110.98	170.16	2
02	02	99	FUEL COMB. INDUSTRIAL	Oil		39.10	0.00	39.10	2
02	03	01	FUEL COMB. INDUSTRIAL	Gas	natural	1458.60	1430.87	2889.47	2
02	03	02	FUEL COMB. INDUSTRIAL	Gas	process	544.92	0.09	545.01	2
02	03	99	FUEL COMB. INDUSTRIAL	Gas		20.30	0.00	20.30	2
02	04	01	FUEL COMB. INDUSTRIAL	Other	wood/bark waste	156.90	4.06	160.96	2
02	04	02	FUEL COMB. INDUSTRIAL	Other	liquid waste	22.46	0.00	22.46	2
02	04	99	FUEL COMB. INDUSTRIAL	Other		60.70	12.93	73.63	2
03	01	99	FUEL COMB. OTHER	Commercial/Institutional Coal		57.32	16.23	73.54	2
03	02	99	FUEL COMB. OTHER	Commercial/Institutional Oil		47.67	113.19	160.86	2
03	03	99	FUEL COMB. OTHER	Commercial/Institutional Gas		174.16	176.79	350.95	2
03	04	99	FUEL COMB. OTHER	Misc. Fuel Comb. (Except Residential)		39.78	18.54	58.32	2
02	05	99	FUEL COMB. INDUSTRIAL	Internal Combustion		1736.91	1.41	1738.33	3
03	05	99	FUEL COMB. OTHER	Residential Wood			5.20	5.20	4
03	06	01	FUEL COMB. OTHER	Residential Other	distillate oil		49.96	49.96	4
03	06	02	FUEL COMB. OTHER	Residential Other	natural gas		102.10	102.10	4
03	06	99	FUEL COMB. OTHER	Residential Other			35.13	35.13	4
04	01	99	CHEMICAL & ALLIED PRODUCT MFG	Organic Chemical Mfg		63.13	0.07	63.20	5
04	02	99	CHEMICAL & ALLIED PRODUCT MFG	Inorganic Chemical Mfg		33.58	0.00	33.58	6
04	03	99	CHEMICAL & ALLIED PRODUCT MFG	Polymer & Resin Mfg		22.06	0.00	22.06	7
04	04	99	CHEMICAL & ALLIED PRODUCT MFG	Agricultural Chemical Mfg		205.51	0.00	205.51	8
04	05	99	CHEMICAL & ALLIED PRODUCT MFG	Paint, Varnish, Lacquer, Enamel Mfg		6.13	0.00	6.13	9
04	06	99	CHEMICAL & ALLIED PRODUCT MFG	Pharmaceutical Mfg		1.27	0.00	1.27	10
04	07	99	CHEMICAL & ALLIED PRODUCT MFG	Other Chemical Mfg		215.29	0.00	215.29	11
05	01	99	METALS PROCESSING	Non-Ferrous Metals Processing		26.25	0.38	26.63	12a
05	02	99	METALS PROCESSING	Ferrous Metals Processing		225.41	0.09	225.50	12b
05	03	99	METALS PROCESSING	Metals Processing NEC		17.56	0.03	17.59	12c
06	01	99	PETROLEUM & RELATED INDUSTRIE	Oil & Gas Production		162.62	1.89	164.52	13
06	02	99	PETROLEUM & RELATED INDUSTRIE	Petroleum Refineries & Related Industries		112.89	0.00	112.89	14
06	03	99	PETROLEUM & RELATED INDUSTRIE	Asphalt Manufacturing		17.86	0.66	18.52	15
07	01	99	OTHER INDUSTRIAL PROCESSES	Agriculture, Food, & Kindred Products		143.20	0.23	143.43	16
07	02	99	OTHER INDUSTRIAL PROCESSES	Textiles, Leather, & Apparel Products		10.05	0.00	10.05	17
07	03	99	OTHER INDUSTRIAL PROCESSES	Wood, Pulp & Paper, & Publishing Products		235.35	0.00	235.35	18
07	04	99	OTHER INDUSTRIAL PROCESSES	Rubber & Miscellaneous Plastic Products		15.33	0.00	15.33	19
07	05	01	OTHER INDUSTRIAL PROCESSES	Mineral Products	cement mfg	294.47	0.00	294.47	20
07	05	02	OTHER INDUSTRIAL PROCESSES	Mineral Products	glass mfg	118.34	0.00	118.34	21
07	05	99	OTHER INDUSTRIAL PROCESSES	Mineral Products		219.86	2.40	222.26	22
07	06	99	OTHER INDUSTRIAL PROCESSES	Machinery Products		11.35	0.30	11.66	23
07	07	99	OTHER INDUSTRIAL PROCESSES	Electronic Equipment		0.12	0.00	0.12	24
07	08	99	OTHER INDUSTRIAL PROCESSES	Transportation Equipment		0.96	0.00	0.96	25
07	10	99	OTHER INDUSTRIAL PROCESSES	Miscellaneous Industrial Processes		16.71	2.00	18.71	26

08	01	99	SOLVENT UTILIZATION	Degreasing		0.84	0.00	0.84	27
08	02	99	SOLVENT UTILIZATION	Graphic Arts		20.71	0.00	20.71	28
08	03	99	SOLVENT UTILIZATION	Dry Cleaning		0.02	0.00	0.02	29
08	04	99	SOLVENT UTILIZATION	Surface Coating		122.04	0.17	122.21	30
08	05	99	SOLVENT UTILIZATION	Other Industrial		0.27	0.00	0.27	31
09	01	99	STORAGE & TRANSPORT	Bulk Terminals & Plants		11.01	0.00	11.01	32
09	02	99	STORAGE & TRANSPORT	Petroleum & Petroleum Product Storage		12.74	0.00	12.74	33
09	03	99	STORAGE & TRANSPORT	Petroleum & Petroleum Product Transport		2.67	0.00	2.67	33
09	04	99	STORAGE & TRANSPORT	Service Stations: Stage I		0.00	0.00	0.00	34
09	05	99	STORAGE & TRANSPORT	Service Stations: Stage II		0.00	0.00	0.00	34
09	07	99	STORAGE & TRANSPORT	Organic Chemical Storage		55.25	0.00	55.25	35
09	08	99	STORAGE & TRANSPORT	Organic Chemical Transport		0.04	0.00	0.04	35
09	09	99	STORAGE & TRANSPORT	Inorganic Chemical Storage		30.90	0.00	30.90	36
09	11	99	STORAGE & TRANSPORT	Bulk Materials Storage		0.00	0.00	0.00	37
09	12	99	STORAGE & TRANSPORT	Bulk Materials Transport		0.00	0.00	0.00	37
10	01	99	WASTE DISPOSAL & RECYCLING	Incineration		117.06	31.21	148.27	38
10	02	99	WASTE DISPOSAL & RECYCLING	Open Burning		0.58	67.06	67.64	39
10	03	99	WASTE DISPOSAL & RECYCLING	POTW		33.71	0.00	33.71	40
10	05	99	WASTE DISPOSAL & RECYCLING	TSDF			0.00	0.00	41
10	06	99	WASTE DISPOSAL & RECYCLING	Landfills		17.33	0.05	17.38	42
10	07	99	WASTE DISPOSAL & RECYCLING	Other		23.26	0.00	23.26	43
14	02	99	MISCELLANEOUS	Other Combustion		0.00	115.68	115.68	45
12	01	01	OFF-HIGHWAY	Non-Road Gasoline	recreational		13.04	13.04	90
12	01	02	OFF-HIGHWAY	Non-Road Gasoline	construction		114.48	114.48	90
12	01	03	OFF-HIGHWAY	Non-Road Gasoline	industrial		178.93	178.93	90
12	01	04	OFF-HIGHWAY	Non-Road Gasoline	lawn & garden		47.92	47.92	90
12	01	05	OFF-HIGHWAY	Non-Road Gasoline	farm		49.42	49.42	90
12	01	06	OFF-HIGHWAY	Non-Road Gasoline	light commercial		12.84	12.84	90
12	01	07	OFF-HIGHWAY	Non-Road Gasoline	logging		0.19	0.19	90
12	01	08	OFF-HIGHWAY	Non-Road Gasoline	airport service		4.72	4.72	90
12	01	09	OFF-HIGHWAY	Non-Road Gasoline	recreational marine vessels		69.30	69.30	90
12	01	99	OFF-HIGHWAY	Non-Road Gasoline			16.25	16.25	90
12	02	01	OFF-HIGHWAY	Non-Road Diesel	recreational		2.02	2.02	90
12	02	02	OFF-HIGHWAY	Non-Road Diesel	construction		2615.03	2615.03	90
12	02	03	OFF-HIGHWAY	Non-Road Diesel	industrial		233.21	233.21	90
12	02	04	OFF-HIGHWAY	Non-Road Diesel	lawn & garden		16.92	16.92	90
12	02	05	OFF-HIGHWAY	Non-Road Diesel	farm		650.28	650.28	90
12	02	06	OFF-HIGHWAY	Non-Road Diesel	light commercial		35.51	35.51	90
12	02	07	OFF-HIGHWAY	Non-Road Diesel	logging		8.28	8.28	90
12	02	08	OFF-HIGHWAY	Non-Road Diesel	airport service		253.11	253.11	90
12	03	99	OFF-HIGHWAY	Aircraft			268.84	268.84	90
12	04	02	OFF-HIGHWAY	Marine Vessels	diesel		281.77	281.77	90
12	04	03	OFF-HIGHWAY	Marine Vessels	residual oil		62.26	62.26	90
12	05	99	OFF-HIGHWAY	Railroads			1521.58	1521.58	90
							total =	38221.66	
							+ mobile	13013.24	
							TOTAL =	51234.90	

Boilers - A'' Non-Utility NOx E… 30 TPSD Potential Reduction - % Capital Cost - $/mmbtu/hr Annual Cost - $/mmbtu/hr/yr Cost Effectiveness - $/ton	annual tuning (1)	low nox burners (LNB) (2)	low excess air (3)	radiant burners (4)	burners out of service (5)	air (6)	…e gas recirc. (7)	water injection (8)	steam injection (9)	reburn (10)	SCR (11)	SNCR (12)	fuel: nat. gas *** (13)	fuel: ultra-low diesel (14)	de… ** (15)	COMMENTS …d example RACT limit
Secondary Impacts under optimal NOx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions		I (CO & HC)	I (CO & HC)	N	R	I (CO & HC)	N	I (CO)	I (CO)	R	I	I	R	R	R	All CA area regs. specifiy li… of 0.15 mmbtu/hr or less; m… for boilers greater than 10 mmbtu/hr
Boilers																
Natural Gas: 10 mmbtu/hr (packaged watertube)	x	50 5850 1190 9030-11300	5-35 2500 387 7360-14700	70-80 3600 1060 5020-5730			50-65 6110 1480 9360-11200	25-50 2500 627 5960-7950	25-50 2500 627 5960-7950					40-65 0 1-300 0-2000 *	x	
Natural Gas: 50 mmbtu/hr (packaged watertube)	x	50 2320 470 2560-3200	5-35 500 -18 <0	80 6730 1960 6670-7630		20-40	50-65 4460 1000 4540-5450	25-50 500 221 1500-2000	25-50 500 221 1500-2000		80-90 6420 1510 4830-5480	30-60 3300 869 4720-5910		60 0 0-300 0-2000 *	x	0.10-0.43
Natural Gas: 150 mmbtu/hr (field-erected watertube)	x	40-55 1200 243 800-3500	5-35 168 -86 <0	90 6520 1900 3500-3940	10-30 167 94 620-1030	35	50-65 2070 505 1390-3700	25-50 167 154 640-850	25-50 167 154 640-850		80-90 3770 996 2060-5600	30-60 3300 937 3100-6800		40 0 0-300 0-2000 *	x	0.20-0.43
Distillate: 10 mmbtu/hr (firetube)	x	45 5850 1190 5310-6640	5-25 2500 270 3020-6040				15-30 6110 1480 11000-22000	15-35 2500 744 5550-8330	15-35 2500 744 5550-8330				40-65	40-65 0 1-300 0-2000 *	x	0.12
Distillate: 50 mmbtu/hr (packaged watertube)	x	45 2320 470 2750-3440	5-25 500 -136 <0			20-40	15-30 4160 1000 9780-19600	15-35 500 338 3900-4950	15-35 500 338 3900-4950		80-90 6420 1510 5200-5890	30-70 3300 862 5040-6310	60	60 0 0-300 0-2000 *	x	0.12
Distillate: 150 mmbtu/hr (field-erected watertube)	x	45 1200 243 600-750	5-25 167 -203 <0		10-30 167 152 750-1250	25	15-30 2070 505 2060-4130	15-35 167 271 1110-1660	15-35 167 271 1110-1660	80	80-90 3770 1020 1560-1780	30-70 3300 997 2450-3060	40	40 0 0-300 0-2000 *	x	0.20-0.43
Residual Oil: 10 mmbtu/hr (firetube)	x	45 5850 1190 2910-3640	5-25 2500 372 2280-4570				15-20 6110 1480 6040-12100	15-25	15-25				40-65	40-65 0 0-300 0-2000 *	x	LNB+FGR
Residual Oil: 50 mmbtu/hr (packaged watertube)	x	45 2320 470 990-1240	5-25 500 -33 <0			20-40	15-30 4160 1000 3530-7060	15-35 500	15-35 500		80-90 6420 1560 2070-2360	30-70 3300 1040 2190-2740	60	60 0 0-300 0-2000 *	x	0.20-0.43 or LNB+FGR
Residual Oil: 150 mmbtu/hr (field-erected watertube)	x	45 1200 243 490-610	5-25 167 -101 <0		10-30 167 101 100-680	25	15-30 2070 505 1690-3370	15-35	15-35	80	80-90 3770 1030 1290-1480	30-70 3300 1050. 2100-2630	40	40 0 0-300 0-2000 *	x	0.20-0.43
Coal-fired: pulverized coal (500 mmbtu/hr)	x	50 6500 779 760-2900	5-30		10-30	15-30 2060 298 580-1450				60	80-90 12400 2750 1790-6800	30-70 1570 784 870-1450	65	65	x	0.30-0.55 dry-bottom 0.55-1.00 wet-bottom
Coal-fired: stoker (500 mmbtu/hr)	x		5-30			0-30 cost of installation					80-90 11800 2620 1980-2230	30-70 1570 687 940-1170			x	
Process Heaters/Steam Generating Units -- Natural Draft																
Nat. gas: 25 mmbtu/hr	x	30-60 82000 14000 2050-2560	5-20	90+ cnvert to mechanical draft			50-60 convert to mechanical draft				80-90 230000 45000 8190-10920	20-50 convert to mechanical draft			x	0.10-0.20 SCAQMD -> 0.036
Nat. Gas: 75 mmbtu/hr	x	30-60 210000 36000 1720-2160	5-20	90+ cnvert to mechanical draft			50-60 convert to mechanical draft				80-90 440000 97000 5870-7820	20-50 convert to mechanical draft			x	0.10-0.20 SCAQMD -> 0.036
Nat. Gas: 200 mmbtu/hr	x	30-60 350000 61000 1100-1370	5-20	90+ cnvert to mechanical draft			50-60 convert to mechanical draft				80-90 790000 20000 4500-6000	20-50 convert to mechanical draft			x	0.10-0.20 SCAQMD -> 0.036
Distillate Oil: 25 mmbtu/hr	x	30-60 82000	5-20				30-60 convert to				80-90 convert to	30-60 230000	x	x	x	0.10-0.30 SCAQMD -> 0.036

		14000 1430-1790					mechanical draft				mechanical draft	48000 4880-6100				
Distillate Oil: 75 mmbtu/hr	x	30-60 210000 36000 1200-1510	5-20				30-60 convert to mechanical draft				80-90 convert to mechanical draft	30-60 440000 110000 3580-4470	x	x	x	0.10-0.30 SCAQMD -> 0.05
Distillate Oil: 200 mmbtu/hr	x	30-60 350000 61000 770-960	5-20				30-60 convert to mechanical draft				80-90 convert to mechanical draft	30-60 790000 220000 2810-3510	x	x	x	0.10-0.30 SCAQMD -> 0.05
Residual Oil: 25 mmbtu/hr	x	30-60 82000 14000 660-850	5-20				30-50 convert to mechanical draft				75-90 convert to mechanical draft	30-60 230000 50000 2410-3010	x	x	x	0.23-0.40 SCAQMD -> 0.05
Residual Oil: 75 mmbtu/hr	x	30-60 210000 36000 580-720	5-20				30-50 convert to mechanical draft				75-90 convert to mechanical draft	30-60 440000 110000 1790-2230	x	x	x	0.23-0.40 SCAQMD -> 0.05
Residual Oil: 200 mmbtu/hr	x	30-60 350000 61000 370-460	5-20				30-50 convert to mechanical draft				75-90 convert to mechanical draft	30-60 790000 240000 1420-1780	x	x	x	0.23-0.40 SCAQMD -> 0.05
Process Heaters/Steam Generating Units – Mechanical Draft																
Nat. Gas: 25 mmbtu/hr	x	30-60 120000 21000 1650-2070	5-20	90+ 160000 57000 2340-2610			50-60 91000 20000 1300-1550				80-90 380000 77000 3300-3800	20-50 230000 47000 4620-6170			x	0.10-0.20 SCAQMD -> 0.036
Nat. Gas: 75 mmbtu/hr	x	30-60 310000 54000 1390-1740	5-20	90+ 50000 160000 2210-2470			50-60 160000 40000 870-1050				80-90 740000 170000 2600-3500	20-50 440000 100000 3370-4500			x	0.10-0.20 SCAQMD -> 0.036
Nat. Gas: 200 mmbtu/hr	x	30-60 530000 91000 890-1110	5-20	90+ 1300000 420000 2170-2420			50-60 320000 77000 630-750				80-90 1330000 340000 2000-2700	20-50 790000 220000 2640-3510			x	0.10-0.20 SCAQMD -> 0.036
Distillate Oil: 25 mmbtu/hr	x	30-60 120000 21000 1340-1680	5-20				30-60 91000 20000 1580-2100				80-90 380000 83000 2920-3280	30-60 230000 50000 3190-3980	x	x	x	0.10-0.30 SCAQMD -> 0.05
Distillate Oil: 75 mmbtu/hr	x	30-60 310000 54000 1130-1410	5-20				30-60 160000 40000 1070-1420				80-90 740000 160000 21160-2430	30-60 440000 110000 2370-2970	x	x	x	0.10-0.30 SCAQMD -> 0.05
Distillate Oil: 200 mmbtu/hr	x	30-60 530000 91000 720-900	5-20				30-60 320000 77000 770-1020				80-90 1330000 390000 1710-1930	30-60 790000 240000 1900-2370	x	x	x	0.10-0.30 SCAQMD -> 0.05
Residual Oil: 25 mmbtu/hr	x	30-60 120000 21000 800-1000	5-20				30-50 91000 20000 930-1250				75-90 380000 78000 1630-1830	30-60 230000 52000 1950-2440	x	x	x	0.23-0.40 SCAQMD -> 0.05
Residual Oil: 75 mmbtu/hr	x	30-60 310000 54000 670-840	5-20				30-50 160000 40000 630-840				75-90 740000 170000 1180-1330	30-60 440000 120000 1470-1840	x	x	x	0.23-0.40 SCAQMD -> 0.05
Residual Oil: 200 mmbtu/hr	x	30-60 350000 61000 290-360	5-20				30-50 320000 77000 450-600				75-90 1330000 350000 910-1030	30-60 790000 250000 1190-1490	x	x	x	0.23-0.40 SCAQMD -> 0.05

* These cost effectivenesses are for the utilization of Ultra-low diesel as the stand-by fuel. It does not include the full time replacement of the primary fuel.
** Derating usually requires compensation, like additional boilers; this may have a cost penalty or negate reductions achieved.
*** Fuel switching to Natural Gas is unit-specific and could have a significant capital and operating cost penalty, and possibly an energy cost penalty.

ing I.C. Engines and Ga. rbines NOx Emissions = 1738.33 TPSD Potential Reduction - % Capital Cost - $ Annual Cost - $/yr Cost Effectiveness - $/ton	annual tuning (1)	low nox burners (LNB) (2)	water injection (3)	steam injection (4)	(5)	fuel: ultra-low diesel (6)	low-emission combustion (7)	air/fuel ratio (8)	ingit. timing retard (9)	pre-stratified charge (10)	NSCR (11)	electrification (12)	OMMENTS ample RACT limits
Secondary Impacts under optimal NOx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions		N	I (CO)	I (CO)	I	R	R	R	I		I	R	
Reciprocating Internal Combustion Engines - spark ignition													
SI Nat. Gas Rich-Burn 250 hp	x				90-98		70-90 400000 130000 4500-5010	10-40 11000 6000 580-870	0-40 12000 6000 680-1130	80-90 62000 84000 2670-3000	90-98 20000 10000 290-310	100	1.5-2.5 g/bhp-hr
SI Nat. Gas Rich-Burn 1000 hp	x				90-98		70-90 670000 220000 1850-2090	10-40 16000 15000 350-520	0-40 16000 13000 370-610	80-90 130000 110000 880-990	90-98 42000 27000 200-220	100	1.5-2.5 g/bhp/hr
SI Nat. Gas Rich-Burn 4000 hp	x				90-98		70-90 1720000 560000 1190-1340	10-40 25000 45000 270-400	0-40 25000 38000 270-450	80-90 170000 130000 260-300	90-98 130000 96000 180-190	100	1.5-2.5 g/bhp-hr
SI Nat. Gas Lean-Burn 250 hp	x				90 310000 140000 4280-4810		80-93 400000 130000 3970-4460	5-30 74000 26000 3510-4680	0-20 12000 5000 980-4930			100	2.5-3.0 g/bhp-hr
SI Nat. Gas Lean-Burn 1000 hp	x				90 340000 180000 1320-1490		80-93 670000 220000 1610-1820	5-30 78000 31000 1060-1420	0-20 16000 11000 490-1470			100	2.5-3.0 g/bhp-hr
SI Nat. Gas Lean-Burn 4000 hp	x				90 470000 310000 580-660		80-93 '1720000 550000 1030-1150	5-30 94000 53000 450-600	0-20 25000 30000 340-1020			100	2.5-3.0 g/bhp-hr
Reciprocating Internal Combustion Engines - compression ignit													8.0-9.0 g/bhp-hr
CI Diesel 250 hp, continuous (8000 hrs)	x				80-90 190000 99000 4170-4690	80-90 0 74000 2000-2500			20-30 12000 6000 780-1140			100	
CI Diesel 1000 hp, continuous	x				80-90 250000 140000 1460-1640	80-90 0 74000 2000-2500			20-30 16000 13000 420-630			100	
CI Diesel 4000 hp, continuous	x				80-90 510000 300000 780-880	80-90 0 74000 2000-2500			20-30 25000 40000 310-470			100	
CI Diesel 250 hp, peaking (2000 hrs)	x				80-90 190000 49000 8750	80-90 0 18500 2000-2500			20-30 12000 3030 1900			100	
CI Diesel 1000 hp, peaking (2000 hrs)	x				80-90 250000 67000 3000	80-90 0 18500 2000-2500			20-30 16000 5300 830			100	
CI Diesel 4000 hp, peaking (2000 hrs)	x				80-90 510000 140000 1560	80-90 0 18500 2000-2500			20-30 25000 13000 515			100	
CI Diesel 250 hp, peaking (200 hrs)	x				80-90 190000 34000 61000	80-90 0 1850 2000-2500			20-30 12000 2140 13400			100	
CI Diesel 1000 hp, peaking (200 hrs)	x				80-90 250000 45000 20000	80-90 0 1850 2000-2500			20-30 16000 3000 4600			100	
CI Diesel 4000 hp, peaking (200 hrs)	x				80-90 250000	80-90 0			20-30 25000			100	

					92000 10000	1850 2000-2500			5100 2010				
CI Dual Fiel 250 hp	x				80-90 190000 98000 5800-6530		60-80 520000 170000 11370-12990		20-30 12000 5000 950-1420			100	
CI Dual Fuel 1000 hp	x				80-90 250000 130000 1970-2210		60-80 880000 280000 4650-5310		20-30 16000 11000 470-700			100	
CI Dual Fuel 4000 hp	x				80-90 510000 270000 1010-1140		60-80 2210000 710000 2960-3390		20-30 25000 29000 320-480			100	
Gas Turbines													
Gas-fired: 5 MW continuous (8000 hrs/yr)	x	60-90 482000 63400 530-800	70-90 544000 165000 1390-1780	70-90 710000 185000 1560-2000	90 572000 258000 2180-2450	75-85 0 0-300 0-2000 *							
Gas-fired: 25 MW, continuous	x	60-90 1100000 145000 240-370	70-90 1140000 408000 690-880	70-90 1610000 448000 780-970	90 1540000 732000 1230-1390	75-85 0 0-300 0-2000 *							
Gas-fired: 100 MW, continuous	x	60-90 2400000 316000 130-200	70-90 2560000 1180000 500-640	70-90 3900000 1250000 520-670	90 3300000 2190000 920-1030	75-85 0 0-300 0-2000 *							
Gas-fired: 25 MW, peaking (2000 hrs/yr)	x	60-90 1100000 256000 980-1470	70-90 1140000 248000 1670-2150	70-90 1610000 319000 2150-2760	90 1540000 517000 3480-3920	75-80 0 18500 60000 *							
Gas-fired: 100 MW, peaking	x	60-90 2400000 316000 530-800	70-90 2560000 624000 1050-2150	70-90 3900000 813000 1370-1760	90 3300000 1430000 2400-2700	75-80 0 18500 60000 *							
Oil-fired: 5 MW, continuous (8000 hrs/yr)	x		70-90 570000 195000 1000-1300	70-90 745000 200000 1010-1300	90 572000 274000 1390-1560								
Oil-fired: 25 MW, continuous	x		70-90 1210000 547000 560-710	70-90 1730000 514000 520-670	90 1544000 812000 820-920								
Oil-fired: 100 MW, continuous	x		70-90 2800000 1720000 440-560	70-90 4230000 1490000 380-480	90 3302000 2500000 630-710								
Oil-fired: 25 MW, peaking (2000 hrs/yr)	x		70-90 1210000 292000 1190-1520	70-90 1730000 350000 1520-1820	90 1540000 537000 2170-2440								
Oil-fired: 100 MW, peaking	x		70-90 2800000 786000 800-1020	70-90 4231000 917000 930-1190	90 3300000 1510000 1530-1720								

* These cost effectivenesses are for the utilization of Ultra-low diesel as the stand-by fuel. It does not include the full time replacement of the primary fuel.

Resi[illegible]al Fuel Combustion NOx Emissions = 192.39 TPSD *Potential Reduction - %* *Capitol Cost - $* *Annual Cost - $/yr* *Cost Effectiveness - $/ton*	annual tuning (1)	0.09 CARB limit using LNB and LEA tuning on new units (2)	LNB (Perforated) (3)	LNB (Modulating) (4)	Solar Assistance (5)	Solar panels (6)	Electric heat pump (7)	Incentives for incr. turnover (8)	COM[illegible] and example RAC[illegible] [illegible]its
Secondary Impacts under optimal Nx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions		R	R, I (CO & HC)	R, I (CO & HC)	N	N	R		A number of air agencies have set a 0.09 lb/mmbtu limit for new space and water heaters, using LNBs and low excess air tuning. Estimated 50% emissions reduction. SCAQMD est. that 0.02 is possible.
Natural gas water heaters, natural gas space heaters and oil space heaters. (All less than 175,000 btu/hr)	x	50+ 50-300 0 1600	80 2300-7100	70 1200-5800	50+	100 62,500	100		

Cement Mfg. NOx Emissions = 294.47 TPSD *Potential Reduction - %* *Capitol Cost - $* *Annual Cost - $/yr* *Cost Effectiveness - $/ton* There are 213 cement kilns at 98 plants in the U.S.. Over comes from 4 states.	annual tuning (1)	Process Modifications (2)	low nox burners (LNB) (3)	Mid-Kiln firing with LNB (4)	SNCR (Urea) (5)	SNCR (Ammonia) (6)	SCR (7)	staged combust. (8)	COMMENTS
Secondary Impacts under optimal Nx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions			I (CO & HC)	I (CO & HC)	I	I	I	R	There is an ACT.
Long Wet Kiln – 30 tons/clinker/hr	x	<25	20-30 1640 1130	20-40 718 550			80-90 12800000 3600		
Long Wet Kiln – 50	x	<25	20-30 2180 880	20-40 748 450			80-90 17400000 3140		
Long Dry Kiln – 25	x	<25	20-30 1270 1270	20-40 708 610			80-90 9870000 3630		
Long Dry Kiln – 40	x	<25	20-30 1640 970	20-40 728 470			80-90 13110000 3170		
Preheater Kiln – 40	x	<25	20-30 1490 1330		30-70 671 930	30-70 1340 1100	80-90 12000000 4120		
Preheater Kiln – 70	x	<25	20-30 2040 970		30-70 927 790	30-70 1850 910	80-90 16800000 3490		
Precalciner Kiln – 100	x	<25	20-30 1720 1010		30-70 969 880	30-70 1650 980	80-90 19300000 4870	29-46	
Precalciner Kiln – 150	x	<25	20-30 2170 830		30-70 1240 800	30-70 2110 880	80-90 24600000 4400	29-46	

Metals Processing - Ferrous NOx Emissions = 225.51 TPSD *Potential Reduction - %* *Capital Cost - $* *Annual Cost - $/yr* *Cost Effectiveness - $/ton*	annual tuning (1)	low nox burners (LNB) (2)	LNB+FGR (3)	LNB+SNCR (4)	LNB+SCR (5)	low excess air (6)	SCR (7)	SNCR (8)	COMMENTS
Secondary Impacts under optimal NOx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions		I (CO & HC)	N	I	I	I (CO & HC)	I	I	Most Furnaces are 100 to 520 mmbtu/hr
Reheat Furnace -- Preheat air 140 mmbtu/hr	x	33-34 53900 700	55 56500 460			12 33400 1120			
300 mmbtu/hr	x	33-34 85300 520	55 89200 340			12 52300 820			
520 mmbtu/hr	x	33-34 119000 420	55 124000 270			12 72800 660			
Reheat Furnace -- Cold Air 140 mmbtu/hr	x	33 8100 280							
300 mmbtu/hr	x	33 12800 210							
520 mmbtu/hr	x	33 17700 170							
Annealing Furnaces 100 mmbtu/hr	x	50 93000 380	82 93000 230	79 240000 620	96 340000 720		85 260000 630	60 150000 510	
200 mmbtu/hr	x	50 140000 290	82 140000 180	79 410000 520	96 520000 540		85 400000 480	60 260000 450	
300 mmbtu/hr	x	50 180000 240	82 180000 150	79 550000 470	96 660000 460		85 510000 400	60 410000 420	
Galvanizing Furnace -- Preheat air 50 mmbtu/hr	x		77 32000 180						
150 mmbtu/hr	x		77 69000 130						
200 mmbtu/hr	x		77 82000 120						
Galvanizing Furnace -- Cold air 50 mmbtu/hr	x	35 32000 -							
150 mmbtu/hr	x	35 69000 -							
200 mmbtu/hr	x	35 82000 -							

Wood, & Paper Manuf. NOx Emissions = 235.35 TPSD Potential Reduction - % Capitol Cost - $/mmbtu/hr Annual Cost - $/yr Cost Effectiveness - $/ton	annual tuning (1)	Low Escess air with air staging (2)	(3)	SNCR (4)	COMMENTS
Secondary Impacts under optimal NOx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions		I (CO & HC)	I	I	
Recovery Boilers at wood, pulp & paper manuf.	x	0-20		35-60 2500-4300 1000-1600	It is likely that most of these units already employ low excess air and air staging to some degree. Reduction potential could b optimistic.
Industrial Boilers at these facilities can be controlled as is detailed under the section for Industrial Boilers					
Lime Kilns at these facilities can be controlled as is detailed under the section for Cement Manuf.					

Agricultural Chemical Manuf. NOx Emissions = 205.51 TPSD Potential Reduction - % Capitol Cost - $ Annual Cost - $/yr Cost Effectiveness - $/ton	annual tuning (1)	low nox burners (LNB) (2)	low excess air (3)	radiant burners (4)	flue gas recirc. (5)	SCR (6)	NSCR (7)	SNCR (8)	extended absorption (9)	COMMENTS and example RACT limits
Secondary Impacts under optimal NOx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions		I (CO)	I (CO & HC)	N	N	I	I	I		There is an ACT
Ammonia Production - 44 plants in U.S. Primary Reformer, nat. gas fired These process can be controlled as is detailed under the section for Boilers	x	x	x	x	x	x		x		11 of the 44 ammonia plants are located in Louisana
Nitric Acid Production - 64 plants in U.S., about 87% in OTAG 200 tons/day of HNO3	x					44-86 314000 188000 305	94-99 1070000 501000 715		93-97 919000 202000 297	Texas has a limit of 2.0 lb of NOx per ton HNO3 produced, which is about 95% control. NSPS is 3.0 lb/ton.
500 tons/day of HNO3	x					44-86 409000 442000 285	94-99 1860000 1020000 580		93-97 1610000 250000 147	
1000 tons/day of HNO3	x					44-86 553000 714000 231	94-99 2820000 1780000 507		93-97 2470000 257000 76	

Oil and Gas Production NOx Emissions = 164.52 TPSD	annual tuning	SCR	COMMENTS
Secondary Impacts under optimal NOx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increase Non-NOx emissions		I	Most emissions come from Natural Gas compressors in Texas
Natural Gas Production - Compressors	x	x	No detailed control data available

Incineration NOx Emissions = 148.26 Potential Reduction - % Capital Cost - \$ Annual Cost - \$/yr Cost Effectiveness - \$/ton	annual tuning (1)	low excess air (2)	staged combust. (3)	flue gas recirc. (4)	nat. gas reburn (5)	SCR (6)	SNCR (7)	COMMENTS and example RACT limits
Secondary Impacts under optimal NOx reducing conditions N - No impact, R - reduce others in addition to NOx, I - may increse Non-NOx emissions		I (CO & HC)	R	N	R	I	I	
Waste Incinerators (including Municipal, Medical, Hazardous and Sewage Sludge Incineration) (Only units over 100 mmbtu/hr)	x	24-35	24-35	10-25	50-60	45-77	50-75 0.5-1.2M 800-1500	MACT standards for NOx: 0.43 lb/mmbtu for existing mass-burn waterwall units 0.53 lb/mmbtu for existing refuse-derived fuel limits 0.32 for new units Approximately 169 units at 65 plants with capacities of 250 TPD or more (250 TPD =~ 100 mmbtu/hr)

issions lume 1996 x and VOC	Strategy	Cost/Ton to Control	Other Criteria?	Other Criteria?	2005 Emission Reduction

issions lume 1996 x and VOC	Strategy	Cost/Ton to Control	Other Criteria?	Other Criteria?	2005 Emission Reduction

EMISSIONS EVALUATION FOR JULY 8-9, 1996 MEETING

Southeast Pennsylvania Ozone Stakeholders Group

E.H. PECHAN & ASSOCIATES, INC.

PRESENTATION SUMMARY

1. 1990 Emissions (with revisions)
   - Five County Area
   - Ozone Nonattainment Area

2. 1996 Emissions
   - Five County Area

3. Growth Assumptions Affecting 1996 and 2005 Analyses

4. Regional (4-State) Emissions Analyses

5. Candidate Measures and Emissions Evaluation

Table 1
1990 Ozone Season Daily Emissions for the Pennsylvania Counties in the Philadelphia NAA
Tier 2 Source Category Summary

Source Category	Daily Emissions (tons/day) VOC	NOx	CO
FUEL COMB. ELEC. UTIL.	**1.0**	**74.2**	**6.1**
Coal	0.2	38.8	1.5
Oil	0.5	25.6	3.1
Gas	0.0	5.1	0.4
Other	0.0	0.4	0.0
Internal Combustion	0.3	4.4	1.1
FUEL COMB. INDUSTRIAL	**0.8**	**76.0**	**9.3**
Coal	0.0	4.8	0.1
Oil	0.0	10.3	0.9
Gas	0.3	42.8	5.2
Other	0.0	0.7	0.0
Internal Combustion	0.5	17.4	3.1
FUEL COMB. OTHER	**1.0**	**26.8**	**5.8**
Commercial/Institutional Coal	0.0	0.8	0.0
Commercial/Institutional Oil	0.3	10.9	2.6
Commercial/Institutional Gas	0.7	13.6	2.7
Misc. Fuel Comb. (Except Residential)	0.0	0.7	0.2
Residential Other	0.0	0.9	0.3
CHEMICAL & ALLIED PRODUCT MFG	**14.8**	**0.1**	**0.0**
Organic Chemicals	8.8	0.0	0.0
Inorganic Chemicals	0.1	0.1	0.0
Polymers & Resins	0.7	0.0	0.0
Paints, Varnishs, Lacquers, Enamels	1.6	0.0	0.0
Pharmaceuticals	0.8	0.0	0.0
Other Chemicals	2.8	0.0	0.0
METALS PROCESSING	**0.6**	**1.5**	**36.0**
Non-Ferrous Metals Processing	0.2	0.0	0.0
Ferrous Metals Processing	0.5	1.5	36.0
PETROLEUM & RELATED INDUSTRIES	**21.5**	**10.0**	**17.9**
Petroleum Refineries & Related Industries	21.2	9.8	17.7
Asphalt Manufacturing	0.3	0.2	0.2
OTHER INDUSTRIAL PROCESSES	**2.3**	**2.8**	**0.6**
Agriculture, Food, & Kindred Products	1.5	0.0	0.0
Wood, Pulp & Paper, & Publishing Products	0.1	0.0	0.0
Rubber & Miscellaneous Plastic Products	0.6	0.0	0.0
Mineral Products	0.0	2.8	0.6
Machinery Products	0.1	0.0	0.0
Miscellaneous Industrial Processes	0.0	0.0	0.0
SOLVENT UTILIZATION	**223.4**	**0.0**	**0.0**
Degreasing	15.9	0.0	0.0
Graphic Arts	20.7	0.0	0.0
Dry Cleaning	0.8	0.0	0.0
Surface Coating	147.5	0.0	0.0
Other Industrial	3.2	0.0	0.0
Nonindustrial	35.4	0.0	0.0

Table 1 (continued)
1990 Ozone Season Daily Emissions for the Pennsylvania Counties in the Philadelphia NAA
Tier 2 Source Category Summary

	Daily Emissions (tons/day)		
Source Category	VOC	NOx	CO
STORAGE & TRANSPORT	**46.2**	**0.0**	**0.0**
Bulk Terminals & Plants	0.7	0.0	0.0
Petroleum & Petroleum Product Storage	4.7	0.0	0.0
Petroleum & Petroleum Product Transport	14.4	0.0	0.0
Service Stations: Stage I	4.2	0.0	0.0
Service Stations: Stage II	19.6	0.0	0.0
Service Stations: Breathing & Emptying	1.7	0.0	0.0
Organic Chemical Storage	0.4	0.0	0.0
Organic Chemical Transport	0.6	0.0	0.0
WASTE DISPOSAL & RECYCLING	**22.0**	**1.7**	**6.5**
Incineration	1.6	1.6	5.3
Open Burning	0.2	0.1	1.2
POTW	7.8	0.0	0.0
TSDF	12.3	0.0	0.0
Landfills	0.2	0.0	0.0
HIGHWAY VEHICLES	**187.9**	**158.3**	**1710.8**
Light-Duty Gas Vehicles & Motorcycles	167.7	122.9	1503.8
Light-Duty Gas Trucks	14.8	12.4	161.6
Heavy-Duty Gas Vehicles	2.4	2.2	35.0
Diesels	3.0	20.8	10.3
OFF-HIGHWAY	**88.1**	**99.5**	**732.6**
Non-Road Gasoline	69.9	9.0	658.4
Non-Road Diesel	9.8	66.7	44.8
Aircraft	7.2	8.2	27.1
Railroads	1.1	15.6	2.3
MISCELLANEOUS	**2.3**	**0.3**	**12.6**
Other Combustion	2.3	0.3	12.6
TOTAL	**612.0**	**451.2**	**2538.0**

Table 2
1990 Ozone Season Daily VOLATILE ORGANIC COMPOUND Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
FUEL COMB. ELEC. UTIL.	**1.0**	**8.1**
Coal	0.2	3.9
Oil	0.5	1.1
Gas	0.0	0.3
Other		0.0
Internal Combustion	0.3	2.8
FUEL COMB. INDUSTRIAL	**0.8**	**4.3**
Coal	0.0	0.0
Oil	0.0	1.4
Gas	0.3	2.3
Other	0.0	0.0
Internal Combustion	0.5	0.5
FUEL COMB. OTHER	**1.0**	**1.9**
Commercial/Institutional Oil	0.3	0.5
Commercial/Institutional Gas	0.7	0.8
Misc. Fuel Comb. (Except Residential)	0.0	0.1
Residential Wood	0.0	0.5
woodstoves		0.2
other		0.3
Residential Other	0.0	0.2
CHEMICAL & ALLIED PRODUCT MFG	**14.8**	**52.6**
Organic Chemical Mfg	8.8	16.0
ethylene oxide mfg		0.0
phenol mfg	6.6	6.6
terephthalic acid mfg	1.4	1.4
ethylene mfg		0.4
charcoal mfg	0.5	0.5
socmi reactor	0.3	0.8
socmi distillation		0.1
socmi air oxidation processes		0.0
socmi fugitives		2.1
other	0.1	4.2
Inorganic Chemical Mfg	0.1	1.6
Polymer & Resin Mfg	0.7	2.9
polypropylene mfg		0.2
polyethylene mfg	0.5	0.6
polystyrene resins		0.0
synthetic fiber		0.3
styrene/butadiene rubber	0.0	0.5
other	0.2	1.2
Agricultural Chemical Mfg		0.0
Paint, Varnish, Lacquer, Enamel Mfg	1.6	1.6
paint & varnish mfg	1.0	1.0
other	0.6	0.6

Table 2 (continued)
1990 Ozone Season Daily VOLATILE ORGANIC COMPOUND Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
Pharmaceutical Mfg	0.8	1.1
Other Chemical Mfg	2.8	29.4
printing ink mfg	0.2	1.2
fugitives unclassified		2.3
other	2.6	25.9
METALS PROCESSING	**0.6**	**1.7**
Non-Ferrous Metals Processing	0.2	0.4
Ferrous Metals Processing	0.5	1.3
Metals Processing NEC		0.0
PETROLEUM & RELATED INDUSTRIES	**21.5**	**31.5**
Petroleum Refineries & Related Indust	21.2	31.1
vaccuum distillation	1.6	1.6
cracking units	0.0	0.7
process unit turnarounds	0.1	1.5
petroleum refinery fugitives	12.5	13.3
other	7.1	14.0
Asphalt Manufacturing	0.3	0.4
OTHER INDUSTRIAL PROCESSES	**2.3**	**28.4**
Agriculture, Food, & Kindred Products	1.5	4.4
bakeries	0.4	1.3
other	1.2	3.1
Textiles, Leather, & Apparel Products		0.3
Wood, Pulp & Paper, & Publishing Prod	0.1	0.1
Rubber & Miscellaneous Plastic Produc	0.6	1.6
Mineral Products	0.0	0.2
Machinery Products	0.1	0.3
Electronic Equipment		0.4
Miscellaneous Industrial Processes	0.0	21.2
SOLVENT UTILIZATION	**223.4**	**351.0**
Degreasing	15.9	24.9
open top	0.2	0.5
conveyorized		0.7
cold cleaning	0.9	1.3
other	14.9	22.4
Graphic Arts	20.7	26.0
letterpress	0.2	0.2
flexographic	2.2	3.2
lithographic	0.6	0.9
gravure	11.5	12.0
other	6.2	9.7
Dry Cleaning	0.8	3.1
perchloroethylene		0.7
petroleum solvent	0.2	0.5
other	0.5	1.9

Table 2 (continued)
1990 Ozone Season Daily VOLATILE ORGANIC COMPOUND Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
Surface Coating	147.5	223.9
industrial adhesives	0.9	1.2
fabrics	1.9	2.3
paper	23.9	24.8
large appliances	0.1	0.4
magnet wire		0.0
autos & light trucks	0.4	7.4
metal cans	8.9	18.4
metal coil	1.2	1.2
wood furniture	2.9	4.6
metal furniture	7.2	9.7
flatwood products	0.5	1.1
plastic parts	0.3	0.5
large ships	0.3	1.1
aircraft	0.8	1.0
misc. metal parts	2.0	3.9
steel drums		0.0
architectural	30.5	49.3
traffic markings	2.6	5.1
maintenance coatings	4.1	6.7
railroad	0.1	0.2
auto refinishing	16.3	28.4
machinery	2.5	4.3
electronic & other electrical	0.3	0.7
general	2.7	5.9
miscellaneous	0.2	1.1
thinning solvents	1.1	1.1
other	35.9	43.5
Other Industrial	3.2	3.3
Nonindustrial	35.4	69.8
cutback asphalt		2.1
other asphalt		3.4
pesticide application	1.4	10.5
consumer solvents		19.7
other	34.1	34.1
STORAGE & TRANSPORT	**46.2**	**90.2**
Bulk Terminals & Plants	0.7	3.6
fixed roof		2.8
floating roof	0.2	0.2
efr with seals	0.0	0.0
ifr with seals		0.0
underground tanks		0.2
other	0.4	0.4

Table 2 (continued)
1990 Ozone Season Daily VOLATILE ORGANIC COMPOUND Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
Petroleum & Petroleum Product Storage	4.7	12.2
floating roof gasoline	0.7	1.8
floating roof crude	0.3	0.3
efr / seal gasoline	0.0	3.9
efr / seal crude	0.1	0.2
ifr / seal gasoline	0.0	0.0
other	3.6	5.9
Petroleum & Petroleum Product Transpo	14.4	31.1
gasoline loading: balanced / submerged	1.6	1.6
gasoline loading: normal / submerged	0.0	0.8
marine vessel loading: gasoline & crude	5.3	9.1
other	7.6	19.6
Service Stations: Stage I	4.2	7.0
Service Stations: Stage II	19.6	25.5
Service Stations: Breathing & Emptyin	1.7	3.1
Organic Chemical Storage	0.4	6.9
Organic Chemical Transport	0.6	0.8
Inorganic Chemical Storage		0.0
WASTE DISPOSAL & RECYCLING	**22.0**	**46.5**
Incineration	1.6	6.4
Open Burning	0.2	13.5
residential		8.9
other	0.2	4.6
POTW	7.8	9.9
Industrial Waste Water		3.5
TSDF	12.3	12.3
Landfills	0.2	0.8
Other		0.1
HIGHWAY VEHICLES	**187.9**	**366.5**
Light-Duty Gas Vehicles & Motorcycles	167.7	281.0
light-duty gas vehicles	161.0	272.0
motorcycles	6.7	9.0
Light-Duty Gas Trucks	14.7	64.0
ldgt1	8.3	36.0
ldgt2	6.4	28.1
Heavy-Duty Gas Vehicles	2.4	12.3
Diesels	3.0	9.2
hddv	1.4	7.1
lddt	0.2	0.2
lddv	1.4	1.8

Table 2 (continued)
1990 Ozone Season Daily VOLATILE ORGANIC COMPOUND Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
OFF-HIGHWAY	**88.1**	**156.6**
Non-Road Gasoline	69.9	123.2
recreational	1.0	2.9
construction	1.8	2.7
industrial	8.1	10.2
lawn & garden	46.9	72.2
farm	0.2	0.5
light commercial		3.8
logging		0.3
recreational marine vessels	11.9	30.6
other		0.1
Non-Road Diesel	9.8	16.0
construction	6.6	10.0
industrial	1.5	1.8
lawn & garden	0.0	0.1
farm	1.7	4.1
light commercial		0.0
Aircraft	7.2	12.8
Marine Vessels		2.2
diesel		1.5
residual oil		0.7
Railroads	1.1	2.3
MISCELLANEOUS	**2.3**	**6.3**
Other Combustion	2.3	4.4
structural fires	2.3	3.3
slash/prescribed burning		0.0
forest wildfires	0.0	1.0
cigarette smoke		0.1
Catastrophic/Accidental Releases		1.8
Health Services		0.0
TOTAL	**612.0**	**1145.7**

Table 3
1990 osd emissions from the Philadelphia NAA
Major Source Category Summary

Pollutant	Source	PA counties	All Counties
voc	area	274.1	499.1
	point	150.0	280.1
	mobile	187.9	366.5
	total	**612.0**	**1145.7**
nox	area	122.9	212.4
	point	170.0	572.7
	mobile	158.3	305.3
	total	**451.2**	**1090.4**
co	area	755.6	1288.9
	point	70.6	167.2
	mobile	1710.8	2971.9
	total	**2537.0**	**4428.0**

Table 4
1990 Ozone Season Daily CARBON MONOXIDE Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
FUEL COMB. ELEC. UTIL.	**6.1**	**28.3**
Coal	1.5	10.9
Oil	3.1	6.3
Gas	0.4	1.4
Other	0.0	0.3
Internal Combustion	1.1	9.4
FUEL COMB. INDUSTRIAL	**9.3**	**37.6**
Coal	0.1	0.4
Oil	0.9	2.3
Gas	5.2	31.4
Other	0.0	0.2
Internal Combustion	3.1	3.2
FUEL COMB. OTHER	**5.8**	**12.3**
Commercial/Institutional Coal	0.0	0.0
Commercial/Institutional Oil	2.6	3.1
Commercial/Institutional Gas	2.7	3.7
Misc. Fuel Comb. (Except Residential)	0.2	0.2
Residential Wood		4.1
woodstoves		1.6
other		2.5
Residential Other	0.3	1.1
CHEMICAL & ALLIED PRODUCT MFG	**0.0**	**30.4**
Organic Chemical Mfg		2.5
Inorganic Chemical Mfg	0.0	27.5
pigments; TiO2 chloride process: reactor		27.5
other	0.0	0.0
Polymer & Resin Mfg		0.0
Pharmaceutical Mfg		0.1
Other Chemical Mfg		0.3
METALS PROCESSING	**36.0**	**36.0**
Ferrous Metals Processing	36.0	36.0
gray iron cupola	12.7	12.7
other	23.3	23.3
Metals Processing NEC		0.0
PETROLEUM & RELATED INDUSTRIES	**17.9**	**34.3**
Petroleum Refineries & Related Industrie	17.7	34.0
fcc units	16.7	33.0
other	1.0	1.0
Asphalt Manufacturing	0.2	0.3

Table 4 (continued)
1990 Ozone Season Daily CARBON MONOXIDE Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
OTHER INDUSTRIAL PROCESSES	**0.6**	**0.6**
Agriculture, Food, & Kindred Products		0.0
Mineral Products	0.6	0.6
Miscellaneous Industrial Processes		0.0
SOLVENT UTILIZATION	**0.0**	**0.0**
Graphic Arts	0.0	0.0
Surface Coating	0.0	0.0
Other Industrial	0.0	0.0
WASTE DISPOSAL & RECYCLING	**6.5**	**65.4**
Incineration	5.3	6.6
industrial	0.0	0.5
commmercial/institutional	0.0	0.9
other	5.2	5.3
Open Burning	1.2	58.8
residential		25.3
other	1.2	33.5
HIGHWAY VEHICLES	**1710.8**	**2971.9**
Light-Duty Gas Vehicles & Motorcycles	1503.8	2284.5
light-duty gas vehicles	1479.3	2254.5
motorcycles	24.5	30.0
Light-Duty Gas Trucks	161.6	503.3
ldgt1	95.0	294.1
ldgt2	66.6	209.3
Heavy-Duty Gas Vehicles	35.0	147.2
Diesels	10.3	36.9
hddv	6.4	32.0
lddt	0.3	0.5
lddv	3.6	4.4
OFF-HIGHWAY	**731.6**	**1186.4**
Non-Road Gasoline	657.4	1068.0
recreational		6.6
construction	21.3	32.3
industrial	170.9	202.1
lawn & garden	428.1	652.7
farm	2.2	5.1
light commercial		63.3
logging		0.8
recreational marine vessels	34.9	104.9
other		0.1

Table 4 (continued)
1990 Ozone Season Daily CARBON MONOXIDE Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
Non-Road Diesel	44.8	71.7
construction	30.7	46.7
industrial	7.2	8.5
lawn & garden	0.2	0.3
farm	6.7	16.0
light commercial		0.3
Aircraft	27.1	38.0
Marine Vessels		4.8
diesel		3.4
residual oil		1.3
Railroads	2.3	4.0
MISCELLANEOUS	**12.6**	**24.9**
Other Combustion	12.6	24.9
structural fires	12.5	18.2
slash/prescribed burning		0.7
forest wildfires	0.1	5.8
cigarette smoke		0.2
TOTAL	**2537.0**	**4428.0**

Table 5
1990 Ozone Season Daily OXIDES OF NITROGEN Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
FUEL COMB. ELEC. UTIL.	**74.2**	**367.4**
Coal	38.8	215.2
bituminous	28.6	205.0
anthracite & lignite	10.2	10.2
Oil	25.6	60.5
residual	24.5	52.9
distillate	1.1	7.6
Gas	5.1	17.6
natural	2.1	10.3
process	3.0	7.4
Other	0.4	9.9
Internal Combustion	4.4	64.2
FUEL COMB. INDUSTRIAL	**76.0**	**176.9**
Coal	4.8	9.5
bituminous	4.5	5.9
anthracite & lignite	0.3	0.3
other		3.4
Oil	10.3	23.4
residual	5.4	14.0
distillate	0.3	3.1
other	4.6	6.4
Gas	42.8	123.7
natural	24.7	66.6
process	18.1	57.1
Other	0.7	2.0
liquid waste	0.7	0.8
other		1.2
Internal Combustion	17.4	18.2
FUEL COMB. OTHER	**26.8**	**38.3**
Commercial/Institutional Coal	0.8	0.8
Commercial/Institutional Oil	10.9	14.1
Commercial/Institutional Gas	13.6	18.5
Misc. Fuel Comb. (Except Residential)	0.7	1.0
Residential Wood		0.0
Residential Other	0.9	3.8
distillate oil		1.0
natural gas		1.7
other	0.9	1.1

Table 5 (continued)
1990 Ozone Season Daily OXIDES OF NITROGEN Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
CHEMICAL & ALLIED PRODUCT MFG	**0.1**	**10.9**
Organic Chemical Mfg		0.1
Inorganic Chemical Mfg	0.1	0.3
Polymer & Resin Mfg	0.0	0.0
Agricultural Chemical Mfg		0.0
Paint, Varnish, Lacquer, Enamel Mfg		0.0
Other Chemical Mfg		10.5
METALS PROCESSING	**1.5**	**1.6**
Non-Ferrous Metals Processing	0.0	0.0
Ferrous Metals Processing	1.5	1.5
Metals Processing NEC		0.1
PETROLEUM & RELATED INDUSTRIES	**10.0**	**10.8**
Petroleum Refineries & Related Industrie	9.8	10.5
Asphalt Manufacturing	0.2	0.3
OTHER INDUSTRIAL PROCESSES	**2.8**	**4.3**
Agriculture, Food, & Kindred Products	0.0	0.0
Mineral Products	2.8	2.8
glass mfg	1.8	1.8
other	1.0	1.0
Machinery Products	0.0	0.1
Miscellaneous Industrial Processes		1.4
SOLVENT UTILIZATION	**0.0**	**0.4**
Surface Coating	0.0	0.4
Other Industrial	0.0	0.0
STORAGE & TRANSPORT		**0.0**
Organic Chemical Storage		0.0
WASTE DISPOSAL & RECYCLING	**1.7**	**4.7**
Incineration	1.6	1.9
Open Burning	0.1	2.8
HIGHWAY VEHICLES	**158.3**	**305.3**
Light-Duty Gas Vehicles & Motorcycles	122.9	196.2
light-duty gas vehicles	122.0	195.1
motorcycles	0.9	1.1
Light-Duty Gas Trucks	12.4	40.7
ldgt1	7.1	24.2
ldgt2	5.3	16.5
Heavy-Duty Gas Vehicles	2.2	7.4
Diesels	20.8	61.1
hddv	15.4	54.6
lddt	0.5	0.7
lddv	4.9	5.8

Table 5 (continued)
1990 Ozone Season Daily OXIDES OF NITROGEN Emissions for the Philadelphia NAA
Tier 3 Source Category Summary

Source Category	Pennsylvania Counties	All Counties
OFF-HIGHWAY	**99.5**	**169.3**
Non-Road Gasoline	9.0	13.1
recreational	3.5	3.5
construction	0.2	0.2
industrial	4.1	6.1
lawn & garden	0.5	0.7
farm	0.0	0.0
light commercial		0.0
logging		0.0
recreational marine vessels	0.7	2.1
other		0.4
Non-Road Diesel	66.7	111.3
construction	53.1	81.9
industrial	6.4	9.4
lawn & garden	0.3	0.5
farm	6.9	19.0
light commercial		0.4
Aircraft	8.2	9.7
Marine Vessels		13.4
diesel		9.2
residual oil		4.2
Railroads	15.6	21.8
MISCELLANEOUS	**0.3**	**0.6**
Other Combustion	0.3	0.6
TOTAL	**451.2**	**1090.4**

Table 6

Ozone Season Daily Emission Estimates for the Pennsylvania Counties in the Philadelphia NAA

Tier 2 Source Category Summary

Source Category	VOC Emissions 1990	VOC Emissions 1996	NOx Emissions 1990	NOx Emissions 1996	CO Emissions 1990	CO Emissions 1996
FUEL COMB. ELEC. UTIL.	**1.0**	**1.3**	**74.2**	**80.8**	**6.1**	**8.3**
Coal	0.2	0.2	38.8	38.6	1.5	2.1
Oil	0.5	0.7	25.6	33.2	3.1	4.5
Gas	0.0	0.0	5.1	5.6	0.4	0.5
Other	0.0	0.0	0.4	0.4	0.0	0.0
Internal Combustion	0.3	0.4	4.4	3.1	1.1	1.2
FUEL COMB. INDUSTRIAL	**0.8**	**0.8**	**76.0**	**45.2**	**9.3**	**9.4**
Coal	0.0	0.0	4.8	3.4	0.1	0.2
Oil	0.0	0.0	10.3	5.9	0.9	0.9
Gas	0.3	0.3	42.8	23.6	5.2	5.0
Other	0.0	0.0	0.7	0.6	0.0	0.0
Internal Combustion	0.5	0.5	17.4	11.7	3.1	3.3
FUEL COMB. OTHER	**1.0**	**1.0**	**26.8**	**25.6**	**5.8**	**5.9**
Commercial/Institutional Coal	0.0	0.0	0.8	0.5	0.0	0.0
Commercial/Institutional Oil	0.3	0.3	10.9	10.1	2.6	2.6
Commercial/Institutional Gas	0.7	0.7	13.6	13.6	2.7	2.8
Misc. Fuel Comb. (Except Residential)	0.0	0.0	0.7	0.4	0.2	0.2
Residential Other	0.0	0.0	0.9	0.9	0.3	0.3
CHEMICAL & ALLIED PRODUCT MFG	**14.8**	**11.6**	**0.1**	**0.1**	**0.0**	**0.0**
Organic Chemicals	8.8	5.8	0.0	0.0	0.0	0.0
Inorganic Chemicals	0.1	0.1	0.1	0.0	0.0	0.0
Polymers & Resins	0.7	0.6	0.0	0.0	0.0	0.0
Paints, Varnishs, Lacquers, Enamels	1.6	1.3	0.0	0.0	0.0	0.0
Pharmaceuticals	0.8	0.8	0.0	0.0	0.0	0.0
Other Chemicals	2.8	2.9	0.0	0.0	0.0	0.0
METALS PROCESSING	**0.6**	**0.6**	**1.5**	**0.9**	**36.0**	**32.2**
Non-Ferrous Metals Processing	0.2	0.1	0.0	0.0	0.0	0.0
Ferrous Metals Processing	0.5	0.4	1.5	0.9	36.0	32.2
PETROLEUM & RELATED INDUSTRIES	**21.5**	**19.6**	**10.0**	**6.0**	**17.9**	**17.8**
Petroleum Refineries & Related Industries	21.2	19.3	9.8	5.8	17.7	17.6
Asphalt Manufacturing	0.3	0.3	0.2	0.2	0.2	0.2
OTHER INDUSTRIAL PROCESSES	**2.3**	**2.2**	**2.8**	**2.1**	**0.6**	**0.6**
Agriculture, Food, & Kindred Products	1.5	1.3	0.0	0.0	0.0	0.0
Wood, Pulp & Paper, & Publishing Products	0.1	0.1	0.0	0.0	0.0	0.0
Rubber & Miscellaneous Plastic Products	0.6	0.7	0.0	0.0	0.0	0.0
Mineral Products	0.0	0.0	2.8	2.1	0.6	0.6
Machinery Products	0.1	0.1	0.0	0.0	0.0	0.0
Miscellaneous Industrial Processes	0.0	0.0	0.0	0.0	0.0	0.0

Table 6 (continued)
Ozone Season Daily Emission Estimates for the Pennsylvania Counties in the Philadelphia NAA
Tier 2 Source Category Summary

	VOC Emissions		NOx Emissions		CO Emissions	
Source Category	**1990**	**1996**	**1990**	**1996**	**1990**	**1996**
SOLVENT UTILIZATION	**223.4**	**208.0**	**0.0**	**0.0**	**0.0**	**0.0**
Degreasing	15.9	15.2	0.0	0.0	0.0	0.0
Graphic Arts	20.7	21.0	0.0	0.0	0.0	0.0
Dry Cleaning	0.8	0.8	0.0	0.0	0.0	0.0
Surface Coating	147.5	131.5	0.0	0.0	0.0	0.0
Other Industrial	3.2	3.3	0.0	0.0	0.0	0.0
Nonindustrial	35.4	36.2	0.0	0.0	0.0	0.0
STORAGE & TRANSPORT	**46.2**	**31.8**	**0.0**	**0.0**	**0.0**	**0.0**
Bulk Terminals & Plants	0.7	0.7	0.0	0.0	0.0	0.0
Petroleum & Petroleum Product Storage	4.7	4.7	0.0	0.0	0.0	0.0
Petroleum & Petroleum Product Transport	14.4	13.8	0.0	0.0	0.0	0.0
Service Stations: Stage I	4.2	4.6	0.0	0.0	0.0	0.0
Service Stations: Stage II	19.6	5.2	0.0	0.0	0.0	0.0
Service Stations: Breathing & Emptying	1.7	1.8	0.0	0.0	0.0	0.0
Organic Chemical Storage	0.4	0.4	0.0	0.0	0.0	0.0
Organic Chemical Transport	0.6	0.6	0.0	0.0	0.0	0.0
WASTE DISPOSAL & RECYCLING	**22.0**	**13.1**	**1.7**	**1.7**	**6.5**	**6.7**
Incineration	1.6	1.6	1.6	1.7	5.3	5.4
Open Burning	0.2	0.2	0.1	0.1	1.2	1.3
POTW	7.8	8.0	0.0	0.0	0.0	0.0
TSDF	12.3	3.1	0.0	0.0	0.0	0.0
Landfills	0.2	0.2	0.0	0.0	0.0	0.0
HIGHWAY VEHICLES	**187.9**	**139.2**	**158.3**	**149.6**	**1710.8**	**987.2**
Light-Duty Gas Vehicles & Motorcycles	167.7	123.9	122.9	119.2	1503.8	866.5
Light-Duty Gas Trucks	14.7	10.7	12.4	11.9	161.6	93.4
Heavy-Duty Gas Vehicles	2.4	1.4	2.2	2.3	35.0	16.2
Diesels	3.0	3.2	20.8	16.3	10.3	11.1
OFF-HIGHWAY	**88.1**	**88.4**	**99.5**	**100.2**	**731.6**	**742.1**
Non-Road Gasoline	69.9	69.1	9.0	9.0	657.4	663.1
Non-Road Diesel	9.8	10.0	66.7	68.2	44.8	45.5
Aircraft	7.2	8.4	8.2	9.5	27.1	31.6
Railroads	1.1	1.0	15.6	13.5	2.3	2.0
MISCELLANEOUS	**2.3**	**2.3**	**0.3**	**0.3**	**12.6**	**12.6**
Other Combustion	2.3	2.3	0.3	0.3	12.6	12.6
Total	**612.0**	**519.9**	**451.2**	**412.5**	**2537.0**	**1822.8**

1996 VOC Emissions Distribution
Five County Area

Source Categories	tpd	Percentage
Fuel Combustion	3.1	0.5%
Industrial Processes	34.0	6.5
Solvent Utilization	208.0	40.0
Storage and Transport	31.8	6.1
Waste Disposal & Recycling	13.1	2.5
Highway Vehicles	139.2	26.8
Off-Highway Vehicles	88.4	17.0
Miscellaneous	2.3	0.4
Total	519.9	100.0%

1996 NO_x Emissions Distribution
Five County Area

Source Categories	tpd	Percentage
Fuel Combustion	151.6	36.8%
Industrial Processes	9.1	2.2
Waste Disposal & Recycling	1.7	0.3
Highway Vehicles	149.6	36.2
Off-Highway Vehicles	100.2	24.3
Miscellaneous	0.3	0.0
Total	412.5	100.0%

Primary Controls Affecting 1996 Emissions

Federal Motor Vehicle Emission Control Program

Current I/M

Phase 1 Federal Reformulated Gasoline

RACT to Major Stationary Sources (> 25 tpy VOC and NO_x)

Stage II Vapor Recovery

Selected Categories	VOC Emissions (tons per summer day) 1990	1996	Percentage Reduction
Highway Vehicles	187.9	139.2	26%
Service Stations	25.5	11.6	55%
RACT to Major Stationary Sources			
	150.0	127.0	15%
Rule Effectiveness Improvements			
Hazardous Waste TSDF Rule	12.3	3.1	75%

15% Plan Measures That Have Not Affected 1996 Emissions

Architectural and Industrial Maintenance Coating

Autobody Refinishing

High Enhanced I/M

Consumer Products Rule

EPA Guidance for Projecting Emissions

Growth Factor Options (in order of preference):

- Product Output
- Value Added
  - revenue minus production costs
- Earnings
- Employment

Summary of Growth Indicators by Source Category

Source Category	Growth Indicator	Level of Detail
Point Sources:		
Nonutility	Earnings by Industry	Pennsylvania
Utility	Fuel Consumption	Mid-Atlantic Region[1]
Area Sources:		
Surface Coating	Employment by Industry	Pennsylvania
Residential/Commercial Combustion	Population	Pennsylvania
Gasoline Distribution	VMT	Pennsylvania
Waste Disposal	Population	Pennsylvania
Graphic Arts	Printing Industry Employment	Pennsylvania
Dry Cleaning	Population	Pennsylvania
Nonindustrial Solvent Use	Population	Pennsylvania
Nonroad Engines:		
Lawn/Garden Equipment	Population	Pennsylvania
Industrial Equipment	Employment - Durable Goods Manufacture	Pennsylvania
Construction Equipment	Employment - Construction	Pennsylvania
Agricultural Equipment	Employment - Agriculture	Pennsylvania
Recreational Vehicles	Population	Pennsylvania
Transportation (Nonroad Vehicles):		
Aircraft	Employment - Air Transportation	Pennsylvania
Marine Vessels	Employment - Water Transportation	Pennsylvania
Railroads	Employment - Rail Transportation	Pennsylvania

NOTE: [1]The Mid-Atlantic Region includes all of New Jersey and Delaware, and the Eastern portions of Maryland and Pennsylvania.

Growth Factors: Development and Application

$$GFACT_{9096} = \frac{GKEY_{96}}{GKEY_{90}}$$

where:

$GFACT_{9096}$ = 1990-1996 growth factor
$GKEY_{96}$ = value of growth indicator in 1996
$GKEY_{90}$ = value of growth indicator in 1990

EXAMPLE: Pennsylvania Population Growth 1990 to 1996

$$POP_{9096} = \frac{12{,}356{,}000}{12{,}091{,}000} = 1.022$$

Summary of Earnings Growth Factors for Significant Non-Utility Point Source Categories by 2-Digit SIC Code

		Growth Factor for:		Percentage of Philadelphia's 1990 Point Source Emissions:	
SIC Code	Industry Name	1990-1996	1990-2005	VOC	NO_x
26	Paper Products	1.077	1.192	15.3%	10.5%
27	Printing/Publishing	1.109	1.264	8.2%	0.0%
28	Chemical Products	1.042	1.119	10.3%	4.7%
29	Petroleum/Coal Products	0.993	1.008	25.8%	28.3%
30	Rubber/Plastic Products	1.124	1.294	3.6%	0.1%
32	Stone, Clay, Glass Products	1.014	1.055	0.1%	1.1%
33	Primary Metal Industries	0.895	0.816	0.5%	8.5%
34	Fabricated Metal Products	1.087	1.173	2.9%	0.0%
36	Electronic Equipment	0.965	0.955	0.8%	0.1%
37	Transportation Equipment	1.047	1.125	0.8%	0.1%
39	Miscellaneous Manufacturing	1.033	1.081	24.8%	0.1%
46	Pipelines, except Natural Gas	1.039	1.094	1.1%	0.0%
51	Wholesale Trade-Nondurables	1.085	1.207	1.3%	0.0%
97	National Security	1.059	1.154	0.8%	2.5%

Growth Factor Summary: Stationary Area Source Categories

Source Category	Growth Indicator	Growth Factor for: 1990-1996	Growth Factor for: 1990-2005	Percentage of Philadelphia's 1990 Area Source Emissions: VOC	Percentage of Philadelphia's 1990 Area Source Emissions: NO_x
Solvent Utilization				42.7%	0.0%
Surface Coating:					
Automotive Refinishing	Population	1.022	1.052		
Traffic Line Painting	Population	1.022	1.052		
Factory Finished Wood	Employment-Durable Goods	0.970	0.938		
Metal Furniture/Fixtures	Employment-Furniture Mfg	1.056	1.125		
Architectural Surface Coating	Population	1.022	1.052		
Electrical Insulation	Employment-Durable Goods	0.970	0.938		
Metal Cans	Employment-Fabricated Metals	1.018	1.014		
Miscellaneous Finished Metals	Employment-Fabricated Metals	1.018	1.014		
Machinery & Equipment	Employment-Nonelectric Machine Mfg	0.973	0.940		
Wood Furniture	Employment-Furniture Mfg	1.056	1.125		
Electrical Appliances	Employment-Electric Machine Mfg	0.911	0.827		
Motor Vehicles	Employment-Motor Vehicle Mfg	0.969	0.926		
Other Transportation	Employment-Other Transportation Equipment	1.128	1.269		
Marine Solvents	Employment-Durable Goods	0.970	0.938		
Railroad Solvents	Employment-Railroads	0.865	0.762		
High Performance Industrial Coatings	Employment-Durable Goods	0.970	0.938		
Miscellaneous Manufacturing	Employment-Durable Goods	0.970	0.938		
Other Special Purpose Coatings	Employment-Durable Goods	0.970	0.938		
Graphic Arts	Employment-Printing	1.054	1.109	2.1%	0.0%
Degreasing	Employment-Durable Goods	0.970	0.938	7.9%	0.0%
Dry Cleaning	Population	1.022	1.052	0.3%	0.0%
Consumer/Commercial Solvent Use	Population	1.022	1.052	19.1%	0.0%

Growth Factor Summary: Stationary Area Source Categories (continued)

Source Category	Growth Indicator	Growth Factor for: 1990-1996	1990-2005	Percentage of Philadelphia's 1990 Area Source Emissions: VOC	NO_x
Other Industrial Processes					
Agriculture, Food & Kindred Products	Employment-Food Manufacturing	0.990	0.965	0.5%	0.0%
Miscellaneous Fuel Combustion					
Commercial/Institutional Oil	Population	1.022	1.052	0.2%	37.8%
Commercial/Institutional Gas	Population	1.022	1.052	0.3%	50.3%
Residential-Other	Population	1.022	1.052	0.0%	3.7%
Storage & Transport					
Service Stations: Stage I	VMT	1.102	1.211	2.3%	0.0%
Service Stations: Stage II	VMT	1.102	1.211	10.5%	0.0%
Petroleum & Petroleum Product Storage	VMT	1.102	1.211	0.0%	0.0%
Petroleum & Petroleum Product Transport	VMT	1.102	1.211	0.1%	0.0%
Service Stations: Breathing & Emptying	VMT	1.102	1.211	0.9%	0.0%
Waste Disposal & Recycling					
Landfills	Population	1.022	1.052	0.1%	0.0%
POTWs	Population	1.022	1.052	4.2%	0.0%
Open Burning	Population	1.022	1.052	0.1%	0.3%
Incineration	Population	1.022	1.052	0.8%	6.7%
TSDFs	Population	1.022	1.052	6.6%	0.0%
Miscellaneous Sources					
Other Combustion	Population	1.022	1.052	1.2%	1.3%
Forest Fires	Zero growth	1.000	1.000	0.0%	0.0%
Structure Fires	Zero Growth	1.000	1.000	0.0%	0.0%

Growth Factor Summary: Nonroad Source Categories

Source Category	Growth Indicator	Growth Factor for: 1990-1996	Growth Factor for: 1990-2005	Percentage of Philadelphia's 1990 Nonroad Emissions: VOC	Percentage of Philadelphia's 1990 Nonroad Emissions: NO_x
Nonroad Gasoline Engines:				79.4%	9.4%
Lawn/Garden	Population	1.022	1.052		
Airport Equip	Employment-Air Transportation	1.164	1.310		
Recreational Eq	Population	1.022	1.052		
Recreational Vessels	Population	1.022	1.052		
Lt. Commercial Eq	Employment-Durable Goods Mfg	0.970	0.938		
Nonroad Diesel Engines:				11.2%	66.8%
Industrial Eq	Employment-Durable Goods Mfg	0.970	0.938		
Construction Eq	Employment-Construction	1.036	1.072		
Agricultural Eq	Employment-Farm	0.967	0.923		
Logging Eq	Employment-Logging	1.088	1.182		
Marine Vessels	Employment-Water Transportation	0.920	0.847		
Aircraft	Employment-Air Transportation	1.164	1.310	8.2%	8.2%
Railroads	Employment-Railroads	0.865	0.762	1.3%	15.6%

Emission Projectic ı: Sample Calculation

$$EMISS_{PY} = EMISS_{BY} * GFACT_{BYPY}$$

where:

$EMISS_{PY}$	=	emissions in the projection year
$EMISS_{BY}$	=	emissions in the base year (1990)
$GFACT_{BYPY}$	=	growth factor from base year to projection year

EXAMPLE: Nonindustrial Solvent Utilization

growth indicator = population = POP_{9096} = 1.022

base year emissions = 35 tons per day (tpd)

$$EMISS_{96} = 35 * 1.022 = 35.77\ tpd$$

Growth Factors for Utility Emissions

- Based on fuel consumption projections by U.S. Department of Energy

- Includes utilities and nonutilities

- Projections for EMM Region Mid-Atlantic Area Council:
  - New Jersey
  - Delaware
  - Maryland (Eastern)
  - Pennsylvania (Eastern)